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ISSUED WEEKLY

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INDEX TO VOLUME XLI

January 1 to June 30, 1915

Explanatory Note

Illustrated articles are marked with an asterisk (*), book notices by a dagger (†), inquiries by a double dagger (‡). The cross-references condense the material and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Blowoff," and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross-reference. A reference from "Oil" to "Lubricating" would apply equally to "Lubrication," "Lubricator," etc. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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ELECTRICITY

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POWER

Vol. 41 NEW YORK, JANUARY 5, 1915 No. 1

Western Newspaper Union Plant in Chicago

By Thomas Wilson

SYNOPSIS—Moving an isolated plant having 525 hp. in boilers and 400-kw. generating capacity while maintaining the service. The operating cost is less than central-station service. An analysis of the plant.

In the summer of 1910 the Western Newspaper Union, which does a general printing and manufacturing business on a large scale, moved into a new building at the corner of Adams and Clinton St., Chicago. In plan, the building measured approximately 125x125 ft. and was eight stories high above the street level. Practically the entire floor space was occupied by the company, and as power was required night and day for the presses, steam for manufacturing and heating, and current for lighting, a private plant was installed.

For three years the plant gave a good account of itself, but late in 1913 the building site was purchased to form part of a tract on which to erect the new Pennsylvania station. As the building was to be torn down the mechanical equipment was moved to a building at Desplaines and Adam St. The latter is five stories high, but as it measures 150x165 ft., the floor space and cubic contents are nearly the same as for the building first occupied.

Past Records Favor Isolated Plant

As is common at such times, strenuous efforts were made by the central station to get its service into the new building. With the printing company it was a question of

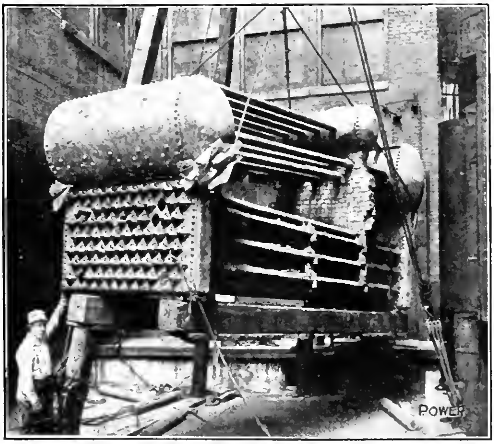


Fig. 1. Moving One of the Water-Tube Boilers

disposing of the generating equipment and accepting the rates offered or moving the plant and continuing to generate its current: this question was thoroughly discussed. Records for three years were available from which to determine the average loads and the cost of operation. Using the rate quoted by the central station, it was an easy matter to obtain an accurate comparison. The figures are not available, but as the station equipment is now being moved, of course, the results favored the isolated plant. Factors influencing the decision were twenty-four-hour service seven days in the week, the use of all exhaust steam for heating except during peak loads and in the summer months, and a demand for steam at 60 lb. pressure in the manufacturing processes. It was seldom

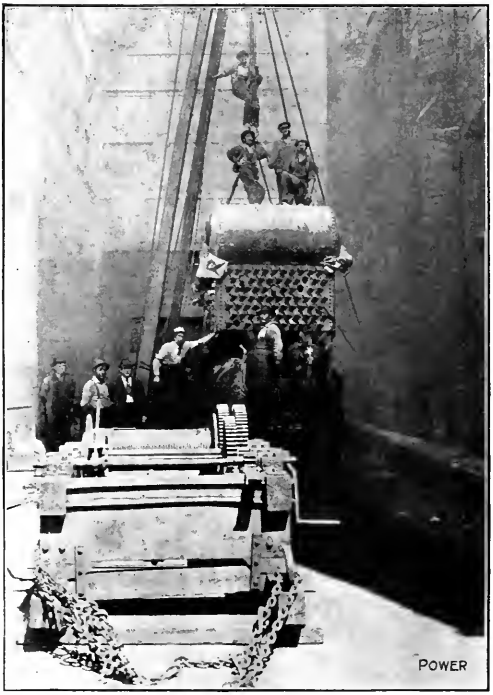


Fig. 2. Hoisting a Boiler onto a Wagon

that live steam was needed to supplement the exhaust, but on the coldest mornings of winter it was used to a limited extent to help heat up the building.

Briefly, the plant equipment consists of three 175-hp. water-tube boilers with extension furnaces and coal-handling equipment, the usual pumps, and in the engine room three direct-current generating units, one rated at 200 kw., a second at 125 kw. and the third at 75 kw. There are four tandem-gear electric elevators, two for passenger service, with a carrying capacity of 2500 lb. at a speed of 250 ft. per min., and two 5000-lb. freight elevators designed for a speed of 150 ft. per min. For freight there is also a 2000-lb. sidewalk lift. A two-pipe vacuum heating system with 16,000 sq.ft. of radiation was put in the building.

Moving the Plant

The above was the power-plant machinery which had to be moved, and to accomplish it without interrupting the service it was necessary to work on Saturday nights and Sundays, when the load was lighter than usual. The equipment was moved a unit at a time and put into operation in the new building. At the present writing more than half of the printing and power-plant machinery has been transferred and is in operation. Two boilers, the largest and smallest generating units and the switchboard have also been moved. It is intended to complete the work very shortly. A temporary switchboard, one boiler and the 125-kw. unit keep the old plant in operation. As a safeguard, breakdown emergency service has been installed. Due to careful planning and working to schedule, the plant has not lost any time to the company.

For moving, the smaller apparatus and generating units were dismantled and then conveyed by wagon to the new site. Wagons also transported the boilers, but as each weighed 34,000 lb., the task was more difficult. After a boiler had been disconnected, the settings knocked down and the furnace removed, it was placed on blocks and skidded under an opening in the driving court provided for the passage of machinery. By means of a derrick over the opening having the usual block and tackle and operated by a winch, the boiler was hoisted onto the wagon, and in much the same way, only with the operations reversed, it was lowered into the new plant. Figs. 1 to 3 will tell the story.

Boiler Room of the New Plant

Fig. 4 shows the layout of the new plant, which differs somewhat from the old, although the installation contains the same machinery. In the Dec. 20, 1910, issue of Power the older plant was described, but as the arrangement differs and additional data are available, a short analysis of the design may be of interest.

In the present plant two of the boilers will be arranged in a battery and the other set singly. Each has 1740 sq.ft. of heating surface and is equipped with a stoker having 33 sq.ft. of grate surface. The ratio is 53 to 1. The operating pressure is 150 lb. gage, although the boilers were designed for 180 lb. At the boiler farthest from the stack, the breeching is 3 ft. wide by 6 ft. high and is widened to 5 ft. at the second boiler, giving an area of 30 sq.ft. The brick stack is 5 ft. in diameter and is 150 ft. above the grate line. Its sectional area is 19.635 sq.ft. To the connected grate surface this area bears a ratio of 1 to 5, a good average figure for Western coal, and for every horsepower of boiler rating there is 0.037 sq.ft., or 5.3 sq.in. of stack area. The breeching dimensions are liberal, as the ratio of breeching area to connected grate is 3 to 10 and of breeching to stack area 3 to 2.

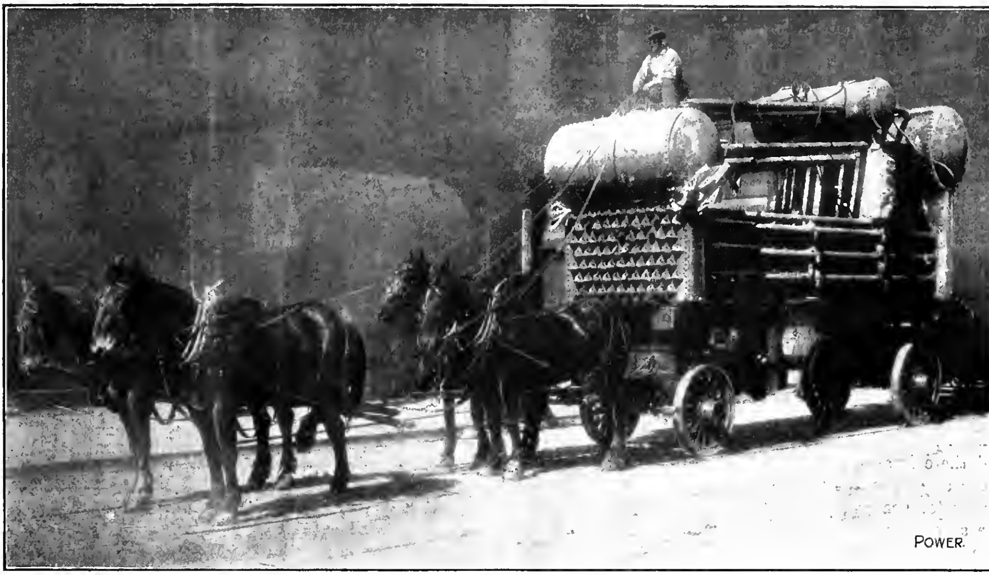


Fig. 3. On the Way to the New Plant

As in the old plant, a damper regulator will be arranged to control the dampers and at the same time the speed of the stoker engines, so that the supply of coal to the grates will be regulated according to the load conditions. When first set up the boilers developed an efficiency of 70 per cent. with coal averaging 11,150 B.t.u.

It is the intention to have complete coal-handling apparatus. Coal is dumped into a bunker, 20x75 and 20 ft. high, under the driving court. It will be carried by wheelbarrow to the boot of an elevator leg delivering to a one-ton traveling and weighing hopper over the furnaces. At present the coal is wheeled from the bunker to the furnaces. A revolving soot blower facilitates cleaning and the ashes will be removed by a bucket elevator rising to the street level and spouting to wagons.

The source of water-supply is the city mains. In winter the returns from the heating system with sufficient make-up is passed to a closed heater having a capacity of 16,000 lb. of water per hour. It is handled by either one of two 7x4½x10-in. duplex pumps, when exhaust steam is needed for heating, and by a 4x6-in. triplex motor-driven pump in the summer months; the latter is naturally more economical of steam. The three pumps are to be so interconnected that any one of them can be used for boiler feed or house purposes. Connection from the pumps will be made to a manifold at the side of one of the boilers, from which point the feed will be controlled. There will also be a city water connection so that the boilers may be filled conveniently after being washed out.

Engine Room

Here the three generating units are arranged as shown in the plan view. The large 200-kw. machine is an angle compound, 17 and 28 by 14 in., running at 260 r.p.m. The other two units, 125 and 75 kw., are driven by simple horizontal engines with cylinders 16x16 in. and 14x12 in. in the order of their size. The speeds are 240 and 275 r.p.m., respectively. Direct current at 230 volts is generated, and duplicate compensating sets, each of 15-kw capacity, will supply lighting current at 115 volts. Besides the elevator motors there is a connected motor load of 450 hp. made up of 175 motors ranging in size from $\frac{1}{8}$ to 40 hp. In the old plant—the load conditions will be practically the same in the new building—the compound unit carried the load during the day, with some help from the 75-kw. machine during the peaks. The latter carried the load at night and the 120-kw. unit was held as a reserve.

Piping

The arrangement of the piping is shown in Fig. 4. From each boiler 6-in. pipes lead into the top of an 8- and 10-in. header which delivers to a secondary 10-in. header in the engine room supplying the three units through 7-, 6- and 5-in. pipes in the order of their size. A 3-in. pipe to the auxiliaries taps the boiler-room header and there is also a couple of connections to supply live steam at reduced pressure to the heating system and the feed-water heater. The exhaust pipes from the engines rise at each unit and eventually join overhead in a 12-in. pipe leading to the heater, the heating system and to the atmospheric exhaust. The location of the valves and the subdivision of the piping will be apparent in the plan view.

It may be of interest to determine the sectional area of the steam pipes per unit of boiler and engine rating and the velocities in the engine supply and exhaust piping. A 6-in. pipe from each boiler allows 0.165 sq.in. per boiler-horsepower. If the boiler were delivering steam at its full rating

$$175 \times 30 = 5250 \textit{ lb. per hr.}$$

or 87.5 per min., would be delivered. At 150-lb. gage pressure this weight of steam would occupy

$$2.758 \times 87.5 = 241.33 \textit{ cu.ft.}$$

and the velocity in feet per minute through the pipe would be

$$241.33 \div 0.2006 = 1203$$

For the engines the following sectional areas of piping for the supply and exhaust have been allowed per kilowatt of rating: 200-kw. unit, supply 0.1937 sq.in., exhaust 0.3943 sq.in.; 125-kw. unit, supply 0.2311 sq.in., exhaust 0.3099 sq.in.; 75-kw. unit, supply 0.2667 sq.in., exhaust 0.3852 sq.in.

To arrive at the approximate velocity of the steam in the piping, assume an average operating rate of 40 lb. per kilowatt-hour for the compound engine and 50 lb. for the two smaller machines. At full load the compound engine would use 8000 lb. of steam per hour, or 133 lb. per min.; the 125-kw. machine 6250 lb. per hr., or 104.2 lb. per min., and the smallest unit 3750 lb. per hr., or 62.5 lb. per min. At 150 lb. gage the volumes of steam passing per minute in the same order would amount to 368, 287 and 172 cu.ft. The velocity of the steam supply in each would then be 1366, 1431 and 1241 ft. per min.,

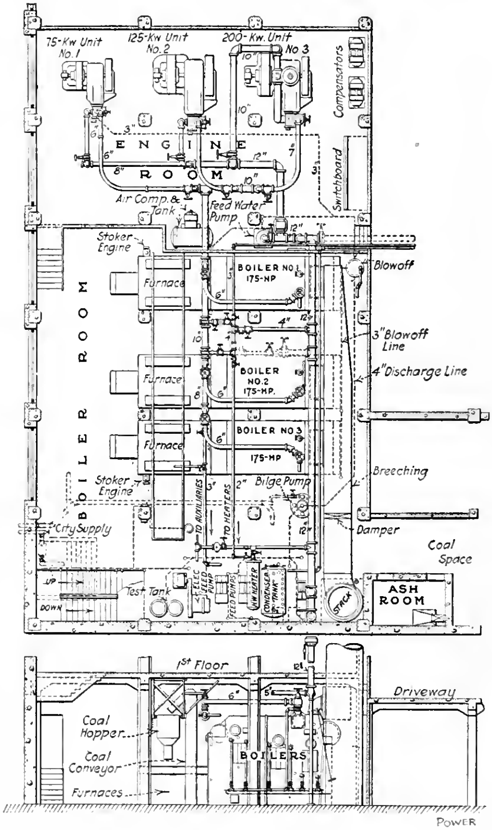


Fig. 4. Plan of Piping and General Layout of the New Plant

assuming, as is usual, that the flow is continuous throughout the stroke. These velocities average 1346 ft. per min. as compared with 6000 ft., the average for current practice. It is evident that the sizes of the supply pipes are liberal, but at the time the plant was installed it was the practice to use large piping and relatively low steam velocities. It must be remembered that with a small receiver the steam flow would be intermittent and the velocity during admission would be practically four times as great as previously indicated. Sudden and heavy overloads and the size of the openings into the cylinder also influence the size of the piping.

With the exhaust at atmospheric pressure, which would be the case in the summer months,

$$133 \times 26.79 \times 0.87 = 3100 \textit{ cu.ft.}$$

of steam per minute would be discharged from the 200-kw. unit. The 26.79 is the cubic feet in a pound of steam at atmospheric pressure and the 0.87 the quality of the steam after expanding adiabatically from 150 lb. gage to atmospheric pressure. As the area of the 10-in. pipe in square feet is 0.5476, the velocity of the steam would be

$$3100 \div 0.5476 = 5661 \textit{ ft. per min.}$$

Figuring in the same way, the 125-kw. unit would discharge 2428 cu.ft. of steam at a velocity of 9026 ft. per min. and the 75-kw. unit 1456 cu.ft. at a velocity of 7261 ft. per min. The average of the three exhaust steam velocities is 7361 ft. per min. This is a little above the usual velocity allowed in the exhaust piping of an engine, but a slight increase in back pressure or running below rating would reduce the volume and consequently the velocity of the steam.

Velocities in steam-engine piping are largely a matter of individual opinion. Since the advent of the steam turbine the tendency has been upward. In these days a velocity of 8000 ft. for the supply is not considered excessive. The exhaust velocity is usually limited to 4000 ft. to prevent friction in the piping and to hold down the back pressure.

Besides the equipment just enumerated there is an air compressor driven by a 20-hp. motor. The machine supplies 100 cu.ft. of air per min. at 100 lb. pressure for operating a pneumatic system, certain machinery in the printing and manufacturing plants and for cleaning the various machines.

PRINCIPAL EQUIPMENT OF WESTERN NEWSPAPER UNION PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Water-tube	175 hp.	Generating steam	Mechanically fired, natural draft, 150-lb. gage	Atlas Water Tube Boiler Co
3	Stokers	Top feed	5½x6 ft.	Boiler furnace	Mechanically operated	Model Stoker Co.
1	Coal elevator	Bucket	15 tons per hr.	Lift coal above furnaces	Motor driven	Jeffrey Mfg. Co.
1	Coal hopper	Traveling and weighing	1 ton	Weigh coal and feed to furnaces		Jeffrey Mfg. Co.
1	Ash elevator	Bucket	10x6-in. buckets	Hoist ashes to street level	Motor driven	Chain Belt Co.
2	Pumps	Duplex	7x4½x10-in.	Boiler feed	150 lb. steam	Piatt Iron Works
1	Pump	Triplex power	4x6-in.	Boiler feed or house service	Driven by 7½-hp motor	Deane Steam Pump Co
1	Heater	Open	16,000 lb. per hr.	Heat boiler feed	Exhaust steam, water 208 deg.	The Griscom Russell Co.
1	Engine	Angle compound	17x28x14-in.	Main unit	150 lb. steam, 260 r p.m.	American Engine & Electric Co.
1	Generator	Direct-current	200 kw.	Main unit	230 volts, 260 r p.m.	American Engine & Electric Co.
1	Engine	Simple horizontal	16x16-in.	Main unit	150 lb. steam, 240 r p m.	American Engine & Electric Co.
1	Generator	Direct-current	125-kw.	Main unit	230 volts, 240 r p.m	American Engine & Electric Co.
1	Engine	Simple horizontal	14x12-in.	Main unit	150 lb. steam, 275 r p.m	American Engine & Electric Co.
1	Generator	Direct-current	75 kw.	Main unit	230 volts, 275 r p.m	American Engine & Electric Co.
2	Elevators	Tandem gear	2500 lb.	Passenger service	250 ft. per min., 40-hp. motor	Western Electric Co
2	Elevators	Tandem gear	5000 lb.	Freight	150 ft. per min., 40-hp. motor	Western Electric Co.
1	Heating system	Two-pipe vacuum	16,000 sq.ft. rad.	Heat building	Exhaust steam	Warren Webster & Co
1	Soot blower	Revolving type		Blow soot off boiler tubes		Vulcan Soot Cleaner Co.
1	Air compressor	Single stage horizontal	6x9¼x10-in.	Compressed air for general use	100 cu.ft. per min. at 100 lb. pressure	National Brake & Electric Co.
1	Motor	Direct-current	20 hp.	Drive air compressor	220 volts, 860 r p.m.	National Brake & Electric Co.

Water for drinking is doubly filtered and cooled. It passes through sand and paper-disk filters in series and is cooled in galvanized-pipe coils laid in an ice box. Bubbling fountains are distributed throughout the building.

For the new layout of the plant as well as the old, and for the moving, Charles G. Atkins, consulting engineer, is responsible.

Will Quizz, Jr.

SYNOPSIS—How Will got his first ideas of engineering, and later learns that faithful plodding does not necessarily bring large success. His conference with Chief Teller on this occasion was not of a technical character, but perhaps it was as vital as any.

"You know, Chief, a boy always has an ideal, and my ideal was to become an engineer like Heintz, the late chief engineer at the gas works.

"When I was a youngster I used to peer longingly through the engine-room window. Heintz would sometimes allow me in the engine room where I would sit in rapture watching the moving machinery—and Heintz. He was a veteran engineer, and my ambition was to be able to wield the long-spouted oil can like he did. You know my pet saying, 'Heintz would do it this way'—but did he do the best way? .

"Since Heintz's enforced retirement, practically on charity, some of the dreams of my childhood have been shattered and I have serious doubts about it. Many good things are said about Heintz, but to me they have brought a flood of doubt. Do I want to follow in his footsteps? Heintz was a fine old character, and his whole career had been in the same engine room. His friends always had seen him in one of three places—at home, in the engine room, or on the path between the two. He worked every Sunday and every holiday; he never had a vacation—never received an increase of pay.

"I notice that his two sons are not following engineering. I am very much bothered as to whether I am on the right track for my life's work. What do you think, Chief?"

"I am glad, Will, that you have so much confidence in me, but it puts a grave responsibility on me too. Everyone has periods of doubt, and evidently you do not want to become an engineer of the Heintz class. It is unfortunate that so little encouragement is offered by some corporations and that there are men so situated or constituted that they will never rise above the lowest grade jobs in any line.

"It is entirely possible, however, for engineers to work reasonable hours, and for them to improve mentally, financially and socially. To avoid becoming disappointed after it is too late to make a change, exert yourself to acquire an engineering education. You will find that the greatest pleasure comes from improving your mind. Cut out those things which will surely leave you stranded and disappointed. You can fire boilers and run an engine and know next to nothing. You can't get on very far in that way. The only hope for a young man to escape the mediocre life is to educate and advance himself day by day.

"There are two elements of greater importance than the trade or occupation—one is the boy (or man) and the other the opportunity or set of conditions surrounding him. When it comes to averaging the load factor of the whole lot of us it's going to be surprising to see how near the maximum some unassuming fellows have been operating with the equipment they had, and under handicaps or unavoidable circumstances of which others may have known nothing.

"I feel sure that you have the right stuff in you, son, to become an engineer worth while, but remember that there can be no excellence without great labor. You have my best wishes and are welcome to any help I can give."

⁂ ⁂

Test of 200-Hp. Gas-Producer Plant

By F. V. Larkin*

SYNOPSIS—Figures showing what may be expected of an anthracite suction producer of this size supplying a four-cylinder, four-stroke-cycle engine under full-load conditions.

During the autumn of 1913 the department of experimental engineering at Lehigh University was called upon to make an acceptance test of a suction producer supplying a 200-hp. gas engine, the object being to ascertain whether the manufacturer's guarantee of capacity, speed regulation and economy was being fulfilled.

TABLE 1. RESULTS OF GAS PRODUCER TEST

Duration of test	24 hr
Kind of coal used	Anthracite pea
Height of the producer	9 ft.
Inside diameter	5 ft., 8 in.
Area of grate	25.2 sq ft.
Air space in grate	29 per cent.
Area of water heating surface in vaporizer	.70 sq.ft.
Rated capacity of producer in lb. of coal per hr	250 lb.
Average Pressures and Temperatures	
Steam pressure in vaporizer	14 lb
Gas pressure in main where measured, in. of water	0 985
Draft in ashpit, in. of water	0 102
	Deg. F
Temperature of water entering vaporizer	166
Temperature of gas in main near producer	584
Temperature of gas where measured	59 7
Temperature of air in producer room	67 7
Temperature of water entering scrubber	53
Temperature of water leaving scrubber	112 9
Weight of dry gas per cu.ft. reduced to 62 deg. and 30 in	0 066 lb.
Hourly Quantities	
Dry coal consumed per hour	206 8 lb
Dry coal consumed per hour per sq.ft. of grate	8 2 lb.
Gas delivered per hour	14,628 cu ft.
Gas per hour at 62 deg. and 30 in	15,520 cu ft.
Weight of dry gas per hour	1,032 lb.
Steam supplied to producer per hour	543 lb.
Water fed to scrubber per hour	2,164 lb
Ultimate Analysis of Dry Coal	Per Cent
Carbon (C)	79 21
Hydrogen (H)	2 01
Oxygen (O)	0 00
Nitrogen (N)	0 80
Sulphur (S)	1 32
Ash	17 37
Moisture in sample of coal as received	2 74
Analysis of Ash and Refuse	Per Cent.
Carbon	39 99
Earthy matter	60 01
Analysis of Gas by Volume	Per Cent.
Carbon dioxide (CO_2)	0 536
Carbon monoxide (CO)	26 760
Oxygen (O)	0 332
Hydrogen (H)	10 944
Marsh gas (CH_4)	1 007
Olefiant gas (C_2H_4)	0 051
Sulphur dioxide (SO_2)	0 000
Hydrogen sulphide (H_2S)	0 000
Nitrogen (N) by difference	61 370
Calorific Values of Coal, B t u per Lb	B t u.
(a) Dry coal by calorimeter	12,363
(b) Wet coal as fired by calorimeter	12,033
(c) Wet coal as fired by Dulong's formula	12,500
Calorific value per lb. of combustible	14,960
Calorific Value of Gas, B t u per Cu Ft at 62 Deg and 30 In.	
(a) By calorimeter	137
(b) By calculation	138 4
Economy Results	Cu Ft.
Total cu.ft. of gas as calculated per lb dry coal fired	70 7
Equivalent cu.ft. of gas at 62 deg and 30 in. per lb dry coal	75
Equivalent cu.ft. of gas at 62 deg and 30 in. per lb of combustible	104 6
Efficiency	Per Cent.
Efficiency of producer based on coal	83 1
Efficiency of producer based on combustible	95 7
Cost of Production	
Cost of coal per ton of 2240 lb. delivered	$3 25
Cost of coal to produce 10,000 cu ft of gas at 62 deg and 30 in	0 199
Cost of coal for producing 1,000,000 B t.u	0 1451
Heat Balance Based on 1 Lb. of Dry Coal	Per Cent.
Heat contained in dry gas	86
Heat carried away by scrubber	9
Heat unaccounted for, including radiation	5

*Assistant Professor of Mechanical Engineering, Lehigh University.

TABLE 2. RESULTS OF GAS ENGINE TEST

Duration of test	24 hr.	
Make of engine	Fairbanks Morse	
Type	Four-stroke cycle	
Size	Four-cylinder 14½x18-in.	
Method of ignition	Battery during test, ordinarily magneto	
Rated capacity	200 hp. at 250 r.p.m.	
Kind of gas (for analysis of gas, see producer test)	Mixed producer gas	
Average Pressures and Temperatures		
Pressure of gas near meter, in. of water	0.985	
Temperature of cooling water	Deg. F.	
(a) Inlet to cylinders and valves	53 74	
(b) Outlet from cylinders	114.56	
(c) Outlet from valves	104.95	
Temperature of gas near meter	62 3	
Temperature of exhaust gases	1019 23	
Gas consumed per hour at 62 deg. and 30 in.	15,520 cu.ft.	
Cooling water supplied per hour		
(a) To jackets	9,000 lb.	
(b) To valves	475 lb	
Analysis of Exhaust Gases by Volume		
	Per Cent.	
Carbon dioxide (CO_2)	16.99	
Oxygen (O_2)	1.84	
Carbon monoxide (CO)	0.50	
Nitrogen (by difference) N_2	80.67	
Indicator Diagrams		
Pressure in lb. per sq.in. above atmosphere		
(a) Maximum pressure	300	
(b) Pressure at end of expansion	25	
(c) Exhaust pressure at lowest point	2	
Average mean effective pressure in lb. per sq.in	59	
Speed and Explosions		
Revolutions per minute	239	
Average number of explosions per min.	478 5	
Indicated horsepower	211.8	
Brake horsepower	199 2	
Friction horsepower by difference	12 6	
Percentage lost in friction	5.8	
Economy Results		
Heat units consumed by engine per hour		
Per indicated horsepower	10,034 B.t.u	
Per brake horsepower	10,674 B.t.u.	
Gas consumed per hour		
Per indicated horsepower	73 3 cu.ft.	
Per brake horsepower	78 cu.ft.	
Dry coal consumed per i hp.-hr	0 98 lb.	
Dry coal consumed per b.hp.-hr	1.04 lb.	
Cost per i hp.-hr	$0 00146	
Cost per b.hp.-hr	$0 00155	
Efficiency		
Thermal efficiency ratio	Per Cent.	
Based on i.hp.-hr	25.3	
Based on brake horsepower	23.8	
Heat Balance Based on B t u. per I Hp.		
	B.t.u.	Per Cent
Heat converted into work	2545	25 4
Heat rejected in cooling water	2700	26 9
Heat rejected in exhaust gases	2582	25 8
Heat lost due to moisture formed by the burning of hydrogen	228	2 2
Heat lost by incomplete combustion	205	2 0
Heat unaccounted for, including radiation	1774	17.7
Total heat consumed per i.hp -hr	10,034	100.0

The plant was put in readiness for the test by the manufacturer's representative, who installed the test flywheels and prony brakes and operated the plant during the test. The university furnished and installed the remainder of the test apparatus, including meters, pitot tubes, gas-analyzing apparatus for fuel and exhaust gases, and the gas calorimeter.

An unusual feature was the means provided to secure continuous determinations of the calorific value of the gas. Continuous samples were drawn from the main by a water aspirator which delivered water and gas to a small tank where the desired pressure was maintained by regulating the water-outlet valve. The calorimeter was of the simple Junker type, with Centigrade thermometers, the wet meter reading to thousandths of a cubic foot, and the water-measuring receptacles graduated in cubic centimeters.

Four preliminary runs of approximately ten hours each at no load, one-fourth, one-half and three-fourths load, respectively, were made to insure satisfactory operation of the plant and test apparatus and to bring the producer up to the condition of every-day operation. Following these runs the final test was made at full rated load and without stops for a period of twenty-four hours. Observations were taken at fifteen-minute intervals during all the tests.

Remarks

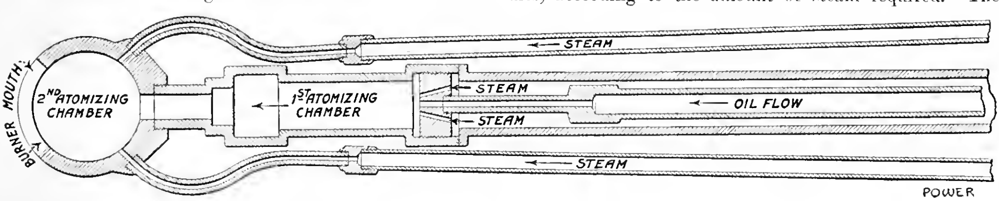
The gas volumes were calculated from the analyses of the coal and gases, because the four pitot tubes installed were so greatly affected by the engine pulsations that their indications were wholly unreliable.

The high mechanical efficiency is probably due, in part at least, to the fact that two of the four indicators used were steam-engine indicators.

It would seem that the manufacturer might arrange to utilize part of the heat lost in the exhaust gases by taking the air necessary for combustion from a preheater surrounding the exhaust gases. In this particular case the owner of the plant can doubtless utilize a sufficient amount of this heat to furnish the hot water necessary for shower baths and other purposes.

Champion Oil Burner

This oil burner is designed to atomize the fuel oil twice during its passage through the burner and also to control the size and shape of the flame. The illustration is a sectional view of the burner.



Section through Champion Oil Burner

As shown, there are two atomizing chambers. The steam comes into the first from above and below the oil-supply pipe, and the mixture then passes to the burner head. Just before it leaves this head it comes in contact with the two jets of live steam from the two side pipes which enter the burner head in the second atomizing chamber, where the mixture is again atomized as it goes to the mouth of the burner.

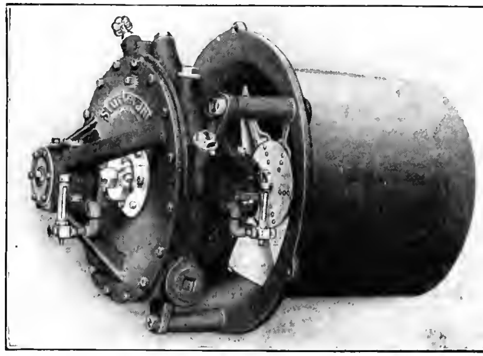
In addition to atomizing the oil the second time, the steam from the two side pipes gives the operator control of the blaze. By closing the valves on these two pipes the blaze will shoot straight back into the furnace, but by opening them the shape of the blaze is controlled. The burner works in connection with a pump and pressure tank, is made to fit any furnace, and is easily placed.

This burner is manufactured by the Champion Oil Burner Co., Kingman, Kan.

Sturtevant Turbo Undergrate Blower

A new design of undergrate blower for use where more furnace draft is needed is placed in the boiler brickwork.

In this set (see illustration), which is made by the B. F. Sturtevant Co., Hyde Park, Boston, Mass., the turbine is practically identical with the large standard turbines built by the company. The bearings are provided with oil-ring lubrication, and a floating, metallic stuffing-box prevents steam from getting into the bearings and enables a back pressure of 15 lb. to be carried.


Sturtevant Turbo Undergrate Blower

The new machine is controlled by from one to six nozzles, according to the amount of steam required. The fireman can shut off any number of nozzles to regulate the steam consumption at low loads.

Wrought Iron—Taken for the purpose of general calculations, the average weight of one cubic foot of wrought iron is 480 lb. per cu.ft., or 40 lb. per sq.ft. one inch thick.

Steel—The average weight of one cubic foot of steel is taken as 489.6 lb. per cu.ft., or 40.8 lb. per sq.ft. one inch thick.

More Gas than Oil—Pennsylvania's supply of gas will outlast the state's supply of oil, in the opinion of Roswell H. Johnson, professor of oil and gas production in the School of Mines in the University of Pittsburgh. Pennsylvania stands sixth among the states as a consumer of oil and second as a consumer of gas. Since 1903 the oil supply has been declining, Prof. Johnson declared, while the supply of gas has been increasing. If there were greater markets, he says, more gas could be produced, as the state has large reserves of gas lying in the deeper sands.

Governor-Stop Control and Belt Tightener

This device is designed for the purpose of allowing the governor stop to remain in position to prevent the shutting down of the engine in case of an overload and to remove the stop and allow the governor to fall to its lowest

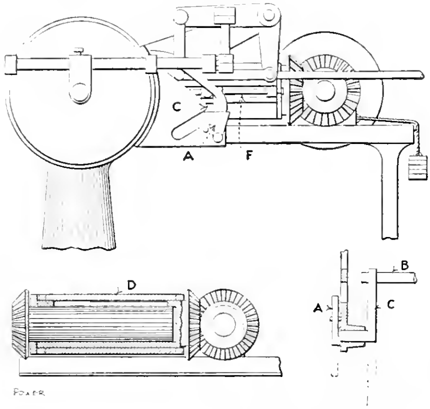


Fig. 1. Details of the Governor-Stop Control

position to stop the engine in case the governor belt breaks or runs off the pulley.

Referring to Fig. 1, *A* represents the governor stop in a position to reverse the governor with the engine stopped. The dotted lines show the governor stop in its lowest po-

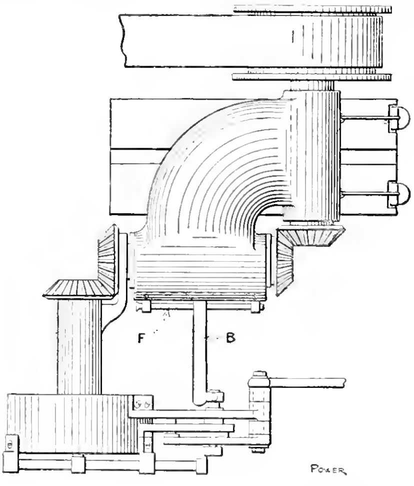


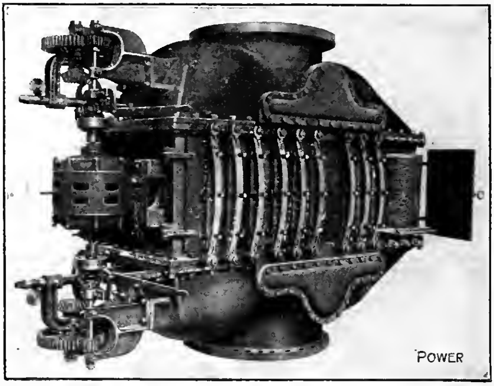
Fig. 2. Plan View of the Stop Control

sition. The stop receives motion from the governor-stop controlling rod *B*. When the engine is running and the governor is performing its normal operation, the governor stop will rise in its "up position" with the governor-control pin *B* in contact with the arm *C* of the stop. If the engine should become suddenly overloaded the governor will drop to the governor stop and descend no farther, thus allowing the engine to continue running; in case the governor belt should break or slip off the pulley, the carriage *D* would be shifted on the bed by the weights *E*. This sliding movement of the carriage causes the controlling rod *A* to strike the arm *C* and to move the governor stop out of its elevated position, turning it to the position shown by the dotted lines. Consequently, when the governor drops, it moves to its lowest position and stops the engine. The weights also exert a pull on the governor belt, thus maintaining a proper tension. The stretching of the belt may alter the position of the stop control rod *A*, and this is compensated for by adjusting the screw rod *F* (Fig. 2) which passes through the pin *A*.

Motor-Operated Twin Strainer

Multiple strainers have performed such good service in connection with water-supply lines, condensers, etc., that they are now regarded as desirable in all uptodate installations.

The shifting of the valves on the small twin strainers by hand is simple, whereas on the larger units up to 48



Motor-Operated Twin Strainer

in., the time consumed in changing over from one side to the other is an item and involves considerable manual labor. To overcome these objections, the Elliott Co., Pittsburgh, Penn., has recently adopted a motor drive applicable to all its twin strainers of 20 in. and above.

An electric motor is mounted on one end of the strainer and drives trains of gears communicating with the two valve stems, friction clutches controlling each valve stem independently of the other, and also independently of the motor. Each stem has a device for indicating the position of each valve. The illustration shows one of the baskets partially removed for cleaning purposes.

After the baskets are cleaned and replaced and the doors closed, and it becomes necessary to open up the baskets on the other side of the strainer for cleaning, the motor is started, and at full speed one of the friction clutches is caused to engage the motor shaft, which moves the valve off its seat. This clutch is then released and the other clutch thrown into engagement with the other shaft, which moves the other valve from its seat. Then both friction clutches are thrown into engagement with the motor shaft and the valves are moved together to the opposite side of the strainer.

When the valves are about an inch from their seating position, one clutch is thrown out of service and the full power of the motor is then employed in seating one valve. After it is seated, its clutch is released and the other clutch is thrown into service, which seats the second valve. The motor is then stopped, the doors opened and the baskets cleaned.

When it becomes necessary to shift the valves in the other direction, the rotation of the motor is reversed and the same operation is repeated.

On a 36-in. strainer the time required to start up the motors and shift the valves from one side to the other is 61 seconds, and to take off the doors and remove the baskets, clean and replace them, on this size strainer, requires less than ten minutes. This added to the time for shifting makes the total time needed to clean a 36-in. twin strainer less than eleven minutes, whereas with the hand-operated screws the time would be about three times as long. The time element in changing strainer baskets is important in order to prevent loss of vacuum and of water-supply, especially when the water strained contains large quantities of leaves and other foreign substances during high-water periods.

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Equipment and Methods in Largest Refrigeration System--V

By Charles H. Bromley

SYNOPSIS—A novel gage records the height of brine in the tank, an ordinarily difficult practice due to precipitation of the calcium. A gage of the same general design records the height of water in the condensing water crib, and this together with the manometer tube connected in the suction main enables the operator to avoid low water due to plugged screens. Turbo-generators furnish energy for light and power for the plants, warehouses and Clinton Market. An exceptionally well trained crew operates the plant, maintains it, and rebuilds it as it wears out. The record system is most complete. The article concludes with a description of the lubricating system and ammonia condensers.

Novel Recording Brine Gage

The amount of brine in the suction tank is an indication of the tightness of the system, for if there is a serious leak it will not be long before the brine level will drop perceptibly. To register or record, by pressure by ordinary means, the height of brine in the tank is practically impossible if accuracy is desired, because in time the calcium settles out and, due to its weight, gives readings which are too great. To eliminate error due to calcium, a diaphragm chamber is used in connection with the recording gage, the outfit being shown in Fig. 21. As the

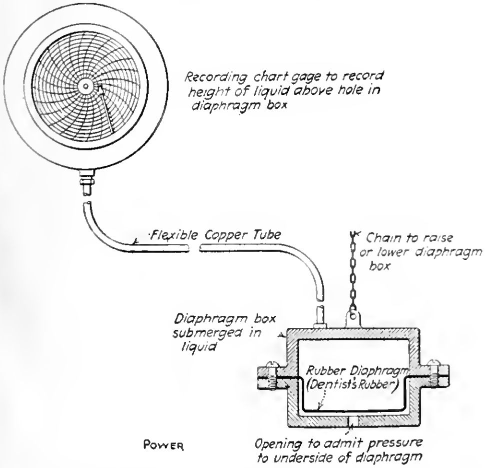


Fig. 21. Section of Type of Gage for Measuring Height of Brine and Condenser Cooling Water

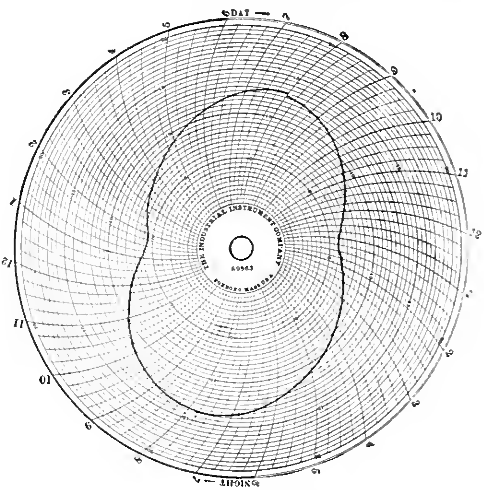


Fig. 22. Chart Showing Rise and Fall of Tide in Crib for Condenser Cooling Water

height of liquid above the hole in the bottom of the diaphragm box increases it pushes up the diaphragm, made of dentist's rubber, thus increasing the air pressure on the recording gage.

Similar Gage Used to Measure Tide

Water for the ammonia and steam condensers is taken from a crib in which the height is governed by the tide. The height in the crib was formerly kept track of by a tide table written on a blackboard in the engine room, but now a record of the tide and the height of water in the crib is recorded by the same kind of outfit as used for measuring the brine. A chart from the tide gage showing the action of the tide on June 18 of this year is shown in Fig. 22. Notice that the maximum high tides for the day differ by a foot and the low tides by 6 in. There are other interesting features if one has the time to study them. Below the gage that records the height of water in the crib is the manometer tube of a venturi meter, Fig. 23. These two gages tell a man all he needs to know about the water condition in the crib and offer him no excuse for losing the water because of dirty screens, as a plugged screen is immediately indicated. A piece of hard black rubber was put in the tube and the instrument calibrated with the rubber floating on the mercury. This makes it easy to quickly get readings.

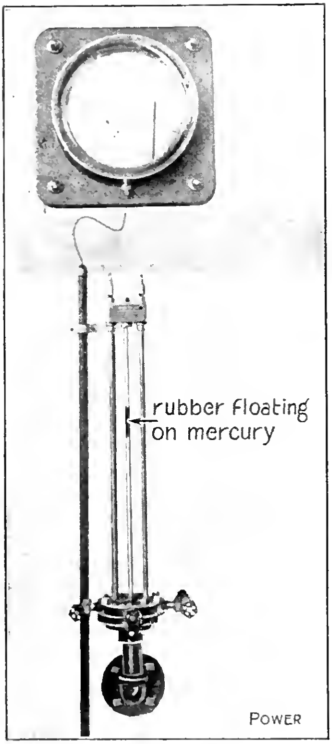


Fig. 23. Manometer Tube of Venturi Meter for Cooling Water Suction Line Placed below Dial Gage That Records Height of Water in Cooling Water Crib

Electric-Generating Equipment

The two main generating sets are turbine driven and are each of 500-kw. capacity, of 450 volts and 3600 r.p.m. Both turbines operate under nearly 29 in. vacuum in winter, 146 lb. pressure and 125 deg. superheat; total temperature, 486 deg. F. Although the superheat at the boilers is 125 deg. F., there is a 15-deg. drop between the superheaters and the turbines. Indicating and recording thermometers are provided in the steam inlet and exhaust pipes.

Two 10-kw. induction motor-driven and one 10-kw. engine-driven, direct-current generators light the station. Light and power as well as refrigeration are furnished to some of the warehouses, and Clinton Market gets its light, power and refrigeration from this station. The switchboard is quite completely fitted, having, besides other instruments, integrating wattmeters, alternating-current load-averaging meters, power-factor meter, graphic voltmeter, syncroscope and a frequency meter. The turbine at the right, Fig. 25, has the distinction of having made a nonstop run for 18 months. The turbines average about 18 lb. steam per kilowatt-hour, and the cost of current is approximately 3/4 cent per kilowatt-hour at the board.

A central surface condensing system is used. Many of the tubes in these condensers have been in service for twelve years and are still in good condition. The tubes are made of a composition consisting of 88 per cent. copper, 10 per cent. tin and 2 per cent. lead, a most unusual composition, for there is seldom more than 1 or 2 per cent. tin and nearly always considerable zinc in condenser tubes, except in some of those brought out recently, namely, aluminum bronze, cupro-nickel and Monel metal. The water in Boston Harbor is quite pure compared to that of the East, Hackensack, Chicago, and other rivers on which there are large condensing plants.

The feed water and the circulating water are measured with venturi meters.

Labor

All labor is departmentized, there being a separate crew for each division of work; the engineers work eight hours and all other employees nine hours a day. The engineers are not allowed to make any mechanical adjustments or repairs except in emergencies: the machinists do all such work. The same is true of all pipe fitting, pipe covering, electrical work, etc.; a separate crew looks after the street system. The company pays for telephones in the homes of all foremen of the crews.

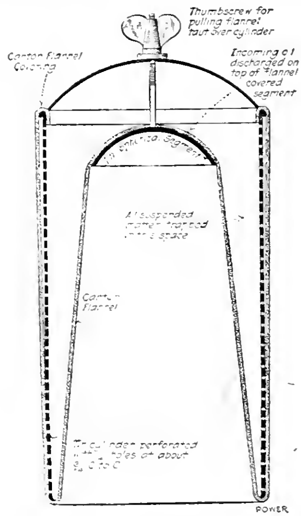


Fig. 24. One of the Perforated Flannel-Covered Cylinders for the Oil Filters

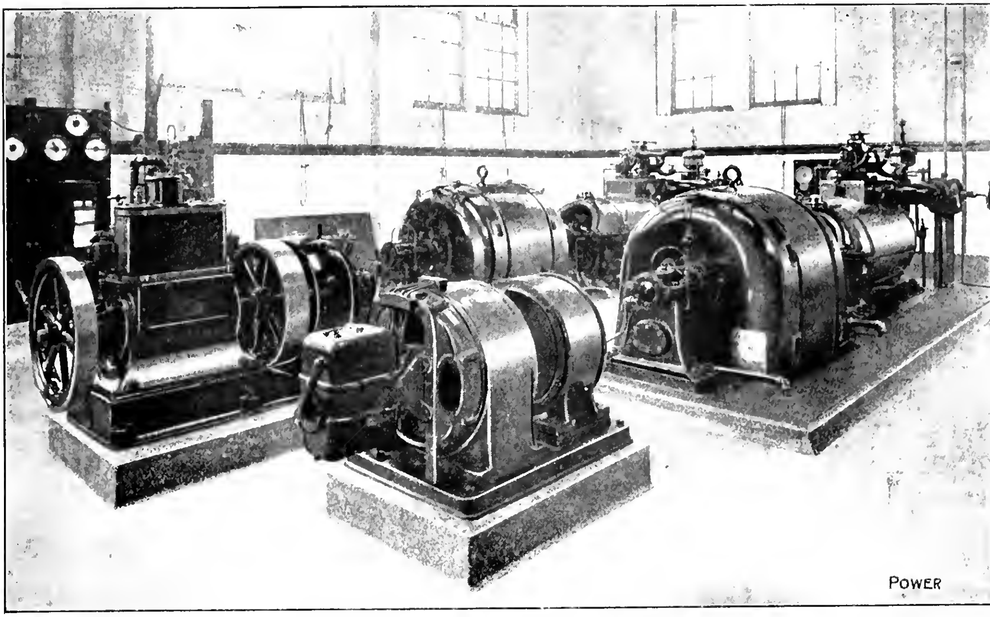


FIG. 25. TURBO-GENERATOR PLANT AT SARGENT'S WHARF
The turbine on the right made a nonstop run of 18 months.

As all except heavy-machine and repair work is done by the different gangs, it enables the company to maintain workmen who in time become trained in team work and thoroughly familiar with the plant. These men do excellent work, too, as is evidenced by even a casual look around the engine room. The lagging, for example, is exceptionally good. Much of the lagging that one finds in plants is made of thin Russian iron, which, after it has been taken off and put on a few times, would exhaust the patience of anyone to get on again. At the Sargent's Wharf plant the iron for the lagging is in heavy sheets and the reinforcing strips used are likewise heavy.

RECORDS

Seven different record forms, including a "summary," are made out daily in the engine room. In addition, there are turned into the chief's office more than a score of charts from recording instruments for various purposes. All record sheets are of uniform size. Reports,

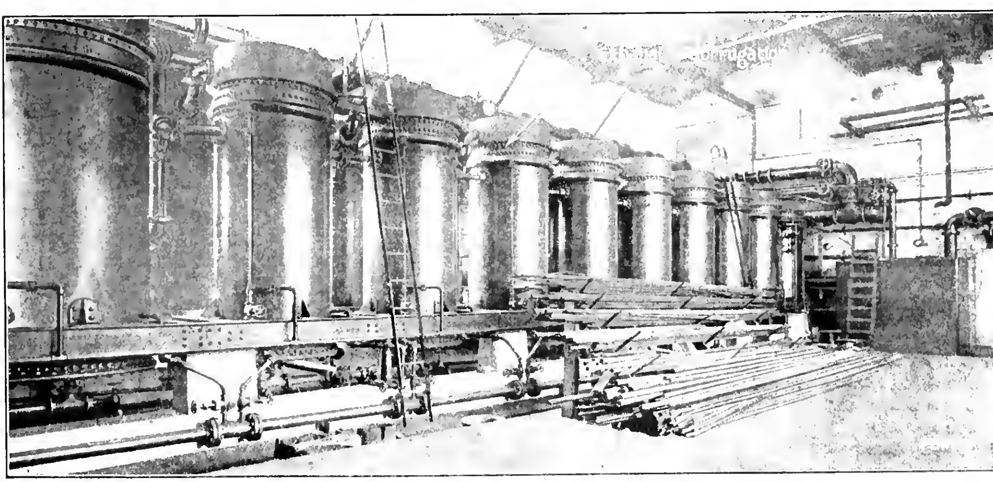
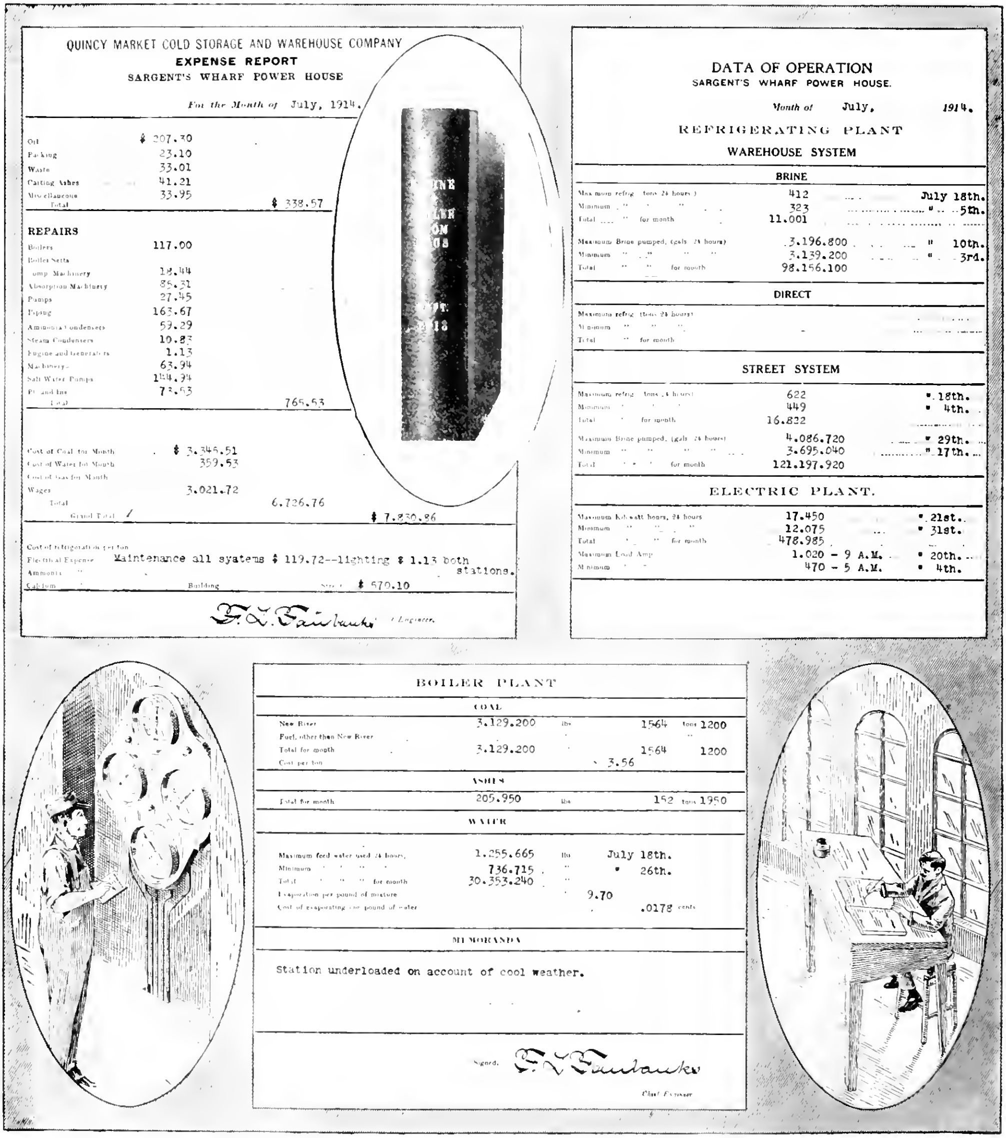


FIG. 26. SHELL-TYPE AMMONIA CONDENSERS
The condensers were built for 300 lb. pressure. Note the expansion corrugation that each has to allow for expansion and contraction

Fig. 27, giving maximum items and costs per units of refrigeration, electricity, water evaporated, etc., are forwarded to the general manager. Report sheets from the engine and boiler rooms are bound in regular book form, size 9½x8 in., shown, and filed in the chief's office; a single volume contains one month's daily reports.

Lubricating Main Bearings

A bearing may be adjusted for running clearance—i.e., clearance enough to allow for smooth running with the brasses and journal at normal temperatures—or it may be given enough clearance so that should it become hot from any cause the expansion of the brasses and journal will not be sufficient to cause the bearing to "freeze" or grip so tightly as to make it unfit for use without much scraping. As pounding frequently accompanies expansion-clearance adjustments, it is the usual practice to adjust for running clearance. No trouble is had so long as the lubricating oil is of proper quality and is supplied in sufficient quantities and no foreign matter gets into the bearing, but sometimes the system oil "wears out" and trouble begins.



QUINCY MARKET COLD STORAGE AND WAREHOUSE COMPANY

EXPENSE REPORT

SARGENT'S WHARF POWER HOUSE

For the Month of July, 1914.

Oil	$ 207.30		
Packing	23.10		
Waste	33.01		
Carting Ashes	41.21		
Miscellaneous	33.95		
Total		$ 338.57	
REPAIRS			
Boilers	117.00		
Boiler Setts			
Comp. Machinery	18.44		
Absorption Machinery	85.31		
Pumps	27.45		
Piping	163.67		
Ammonia Condensers	59.29		
Steam Condensers	10.83		
Engine and Generators	1.13		
Machinery	63.94		
Salt Water Pumps	144.94		
Pt. and Ins.	73.53		
Total		765.53	
Cost of Coal for Month	$ 3.345.51		
Cost of Water for Month	359.53		
Cost of Gas for Month			
Wages	3.021.72		
Total		6.726.76	
Grand Total			$ 7.830.86

Cost of refrigeration per ton

Electrical Expense Maintenance all systems $ 119.72--lighting $ 1.13 both stations.

Ammonia

Calcium Building Street $ 570.10

F. L. Fairbanks, Engineer.

DATA OF OPERATION

SARGENT'S WHARF POWER HOUSE.

Month of July, 1914.

REFRIGERATING PLANT

WAREHOUSE SYSTEM

BRINE

Maximum refrig. (tons 24 hours)	412	July 18th.
Minimum " " "	323	" 5th.
Total " for month	11.001	
Maximum Brine pumped, (gals. 24 hours)	3.196.800	" 10th.
Minimum " " " "	3.139.200	" 3rd.
Total " " for month	98.156.100	

DIRECT

Maximum refrig. (tons 24 hours)		
Minimum " " "		
Total " for month		

STREET SYSTEM

Maximum refrig. (tons 24 hours)	622	" 18th.
Minimum " " "	449	" 4th.
Total " for month	16.822	
Maximum Brine pumped, (gals. 24 hours)	4.086.720	" 29th.
Minimum " " " "	3.695.040	" 17th.
Total " " for month	121.197.920	

ELECTRIC PLANT.

Maximum Kilowatt hours, 24 hours	17.450	" 21st.
Minimum " " "	12.075	" 31st.
Total " " for month	478.985	
Maximum Load Amp.	1.020 - 9 A.M.	" 20th.
Minimum " "	470 - 5 A.M.	" 4th.

BOILER PLANT

COAL

New River	3.129.200	lbs.	1564	tons 1200
Fuel, other than New River		"		"
Total for month	3.129.200		1564	1200
Cost per ton			$ 3.56	

ASHES

Total for month	205.950	lbs.	152	tons 1950

WATER

Maximum feed water used 24 hours,	1.255.665	lbs.	July 18th.
Minimum " " " "	736.715	"	" 26th.
Total " " " for month	30.353.240	"	
Evaporation per pound of mixture		9.70	
Cost of evaporating one pound of water			.0178 cents

MEMORANDA

Station underloaded on account of cool weather.

Signed, F. L. Fairbanks, Chief Engineer

Fig. 27. Some of the Report Forms Used at Sargent's Wharf

All important reports are made on sheets of uniform size and monthly reports are bound as shown by the log book at the top of this illustration.

In many plants where oil is put through filters, returned to the system and used over and over again, serious troubles sometimes arise due to hot bearings. No good reason is evident; the oil is clean and supplied in the usual or even greater quantities, yet nearly all the bearings are hot at the same time. Trouble of this nature frequently happens on a hot summer's day. The reason usually lies in the fact that the system oil has so weakened in viscosity and specific gravity that when an extra warm day comes, with its increase in load, if the plant supplies refrigeration it cannot furnish sufficient lubrication; therefore all bearings with small running clearances and those supporting heavy journals which squeeze out the thin oil overheat.

System Oils Tested Daily

To prevent this trouble in the Quincy Market Co.'s plants the night engineer tests a sample of each system oil each day for the viscosity and specific gravity, the report going to the chief engineer, who will direct that fresh oil be added to increase these properties when the reports show this to be necessary.

Oil Filters

The filters through which the oil finally passes on its way to the engines were made in the plant. Briefly, their construction is this: A tank of oblong section has six canton flannel-covered perforated cylinders set into it, all the cylinders being supported by a sheet-tin partition. Fig. 24 shows how the cylinder is covered with flannel. The oil flows to the cylinder through 5/8-in. brass pipe, a swinging elbow and a nipple instead of a valve being used to stop the oil flow to each of the six cylinders in a filter.

Ammonia Condensers

The present ammonia condensers are of the shell type. Formerly open-coil condensers were used and located in the place now occupied by those of the shell type shown in Fig. 26. To insure a steady flow of water over them, the cooling water was pumped into a large tank at the right of the room and elevated 20 ft. above the condensers, the water gravitating to the latter. When the present condensers were installed this tank was not needed, and as the discharge head was decreased 20 ft., it helped to increase the pump's capacity.

Another advantage following the introduction of the shell-type condenser was that no water was splashed over the floor, on the I-beams, etc. This is more favorable than one may at first believe, but a look at the balcony of the Richmond St. plant, where the structural work was very seriously corroded in only seven years, convinces one that the shell-type condenser is best for the conditions in these two plants.

The condensers are 4 ft. in diameter and contain 367

PRINCIPAL EQUIPMENT OF SARGENT'S WHARF STATION, QUINCY MARKET, COLD STORAGE AND WAREHOUSE CO.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	Watertube "Stirling"	350 hp.	Steam generation	Stoker fired, 140 lb. pres., 125 deg. F. superheat	Babcock & Wilcox Co.
5	Boilers	Scotch	300 hp.	Steam generation	Hand fired, 140 lb. pres., 125 deg. F. superheat	Atlantic Works, Boston
5	Stokers	Underfeed		Boiler furnaces	Bituminous coal—New River, straight	American Engineering Co.
1	Combustion cont'l system	Balanced draft	All ten boilers	Combustion control	With forced-induced draft	Blaisdell-Canady Co.
10	Superheaters	Connected		Superheated steam	140 lb. pres., 125 deg. F. superheat	Foster Engineering Co.
	Economizers	Tube		Feedwater heating	Intake 225 deg. F.; outlet 275 deg. F.	Green Fuel Economizer Co.
10	Feedwater regulators		2-in.	Feedwater flow regulation	140 lb. pressure	Boston Steam Specialty Co.
2	Injectors	Double tube "Buffalo"	2½-in.	Feedwater system emergency	140 lb. pressure, through economizer	Sherwood Mfg. Co.
1	Draft system	Forced-induced.		Boiler purposes	Fan system, 4 in. in ashpits, 0.2 in. over fires	B. F. Sturtevant Co.
1	Feedwater heater	Closed		Primary heating	Inlet 60 deg. F.; outlet 100 deg. F.	Wainwright
2	Draft gages	"Steinbardt"		Draft over fire—recording	0.2 to 0.4 in. connected to "Gascomposmeter"	Uheling Instrument Co.
1	Draft gage	Indicating		Draft over fire—indicating	0.2 to 0.4 in.	Uheling Instrument Co.
1	CO_2 recorder	"Gascomposmeter"		CO_2—recording	Gas taken from main uptake	Uheling Instrument Co.
2	Turbines	Horizontal	500 kw.	Electric generator drive	140 lb. pres., 125 deg. F. superheat, 1120 r.p.m., 28 in. vac	Westinghouse Machine Co.
1	Turbine	Horizontal	135 hp.	Pump drive	140 lb. pres., 1200 r.p.m. condensing	Terry Steam Turbine Co.
1	Ammonia compressor.	Angle-compound	1000 tons	Refrigeration		Providence Engineering Works
1	Ammonia compressor.	Angle-compound	800 tons	Refrigeration		Pennsylvania Iron Works
1	Ammonia compressor.	Angle-compound	400 tons	Refrigeration		Pennsylvania Iron Works
1	Ammonia compressor.	Angle-single		Pumping ammonia from system	General pumping	Frick Engineering Co.
2	Brine pumps	Cross-compo'd, pot type	Each 10,000,000 gal. per day	Brine circulation	Street and warehouse systems	Snow Steam Pump Works
1	Brine pump.	Turbine	8-in.	Emergency brine circulation	Induction motor driven	Worthington Steam Pump Co.
13	Ammonia condensers.	Shell type		Ammonia gas condensation.	Salt-water cooled, series connected	The Bigelow Co.
2	Pumps	Volute	10-in.	Salt water for all cooling	Induction motor driven, 1120 r.p.m.	Wheeler Condenser & Engineering Co.
1	Pump	Volute	14-in.	Salt water for all cooling	Turbine driven, 1200 r.p.m.	Wheeler Condenser & Engineering Co.
1	Pump	Triplex	12x14-in.	Salt water for all cooling	Engine driven	Goulds Mfg. Co.
1	Pump	Duplex-compound, plunger	6½, 10x6-in.	Feedwater system	Automatic control	Snow Steam Pump Works
1	Pump	Triplex	6x10-in.	Feedwater system	Automatic control, motor driven, continuously operated	Goulds Mfg. Co.
2	Pumps	Reciprocating	9, 22x12-in.	Air from surface condenser	28-in. vac.; steam driven.	Wheeler Condenser & Engineering Co.
2	Condensers.	Surface		Central condensing system	Use water from ammonia condensers	Wheeler Condenser & Engineering Co.
2	Generators	Turbo; alternating current	500 kw.	Current for station use.	3600 r.p.m., 440 volts, 2-phase, 60 cycle	Westinghouse Electric & Mfg. Co.
2	Generators	Direct current	10 kw.	Station lighting	1125 r.p.m., 125 volts, 80 amp., motor driven.	Westinghouse Electric & Mfg. Co.
1	Generator	Direct current	10 kw.	Station lighting	1125 r.p.m., 125 volts, 80 amp., engine driven.	Westinghouse Electric & Mfg. Co.
1	Motor	Induction	15 hp.	D.c. generator	1120 r.p.m., 440 volts, 2-phase, 60 cycle	Westinghouse Electric & Mfg. Co.
1	Motor	Induction	200 hp.	Turbine brine pump	440 volts, 2-phase, 60 cycle	Westinghouse Electric & Mfg. Co.
1	Motor	Induction	20 hp.	Triplex feed pumps	1120 r.p.m., 440 volts, 2-phase, 60 cycle	Westinghouse Electric & Mfg. Co.
2	Motors	Induction	100 hp.	Salt water pump	1120 r.p.m., 440 volts, 2-phase, 60 cycle	Westinghouse Electric & Mfg. Co.
1	Switchboard	Gray marble.	Four-panel	Main electrical control	Alternating and direct current	Quincy Market C. S. & W. Co.
5	Engine stops			Compressors and brine pumps		Locke Regulator Co.
1	Engine	Single acting	20 hp.	D.c. generator drive	Station lighting	Westinghouse Machine Co.
1	Air compressor	Single stage	6x6-in.	General service	Steam driven	Ingersoll-Sargent Co.
1	Oil filter	Centrifugal.		Waste oil		Oil & Waste Saving Machinery Co.
1	Waste washer	Centrifugal				Oil & Waste Saving Machinery Co.

Note: The big steel forgings for the 1000-ton compressor were made by the Bethlehem Steel Co.; the steel castings, by the Chester Steel Casting Co.; the very large castings for the bed plate and A-frames by the Farrell Foundry and Machine Co.; the bronze castings by the Philadelphia Phosphor Bronze Smelting Co.; the steam and ammonia cylinders by the J. C. Colvin Co. and the condensers and coolers by The Bigelow Co., makers of the Hornsby-Bigelow boiler. All piping and valves are of the Quincy Market Cold Storage and Warehouse Co.'s make one and one-half inch Shelby cold-drawn steel tubes, each 8 ft. long; the condensers were built for 300-lb. pressure.

Notice the expansion corrugation in the condenser shell. When the Quincy Market Co. first drew up its specifications, this expansion corrugation was made of heavier metal than the rest of the shell and riveted to it, but experience shows that it is cheaper and better to make the whole shell of the thickness of the corrugation.

An unmistakable error appeared in article III, p. 883. The word "more" in the next-to-the-last line should be "less."

Electromagnets for Alternating-Current Circuits

By Norman G. Meade

SYNOPSIS—Electromagnets in general and sample calculations for the design of a pair of small magnets to operate on a 25-cycle circuit.

Alternating-current electromagnets differ from those used on direct-current circuits, and the calculations for the windings are essentially the same as for the primary winding of a static transformer. The cores are laminated and built up from soft iron or steel punchings, as in Fig. 1, which gives front and side views of a pair of tractive magnets for general use such as actuating mechanisms, lifting purposes, etc.

To secure economical design the electromagnet should conform to established proportions. It is essential that the magnetic circuit be complete and, where space will not permit the use of two coils, the construction shown in Fig. 2 may be used, the one coil serving to excite the consequent pole.

For long-range magnets—that is, where the pull exceeds an inch or more in length—the plunger style of construction, shown in Fig. 3, should be used. On single-

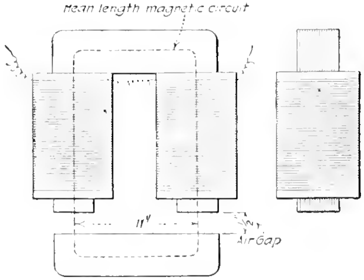


Fig. 1. Pair of Tractive Magnets

phase circuits, or when connected to one phase of a polyphase circuit, plunger magnets will make considerable noise, owing to the oscillations of the plunger. This can be relieved by placing a small compression spring between the plunger and the stop, as shown.

For alarm bells operating from an alternating supply circuit, the polarized electromagnet, shown in Fig. 4, is used. It has the distinctive advantage over direct-current signaling magnets in that no make-and-break contacts are necessary. The coils are wound in a manner similar to the direct-current magnets, but the armature is pivoted at the center and is free to move in both directions. A permanent magnet is attached to the electromagnet yoke; having the form of an elongated U, the lower end being just beneath the armature. When there is no current passing through the coils the cores will correspond in polarity to the permanent magnets as well as the armature, as indicated. When an alternating current flows through the coils, it will tend to strengthen one core and weaken the other at every alternation. The armature will then be drawn up to the strongest core,

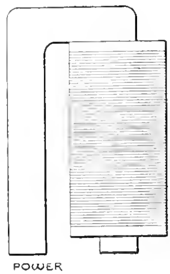


Fig. 2. Single-Coil Electromagnet

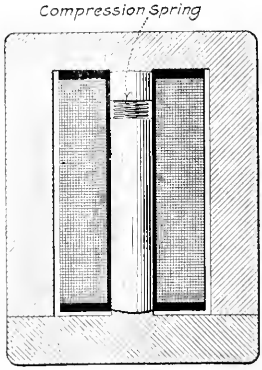


Fig. 3. Plunger Type

causing it to give the striker two vibrations during each cycle.

When the magnet coils are wound on metal spools, the latter should be split from end to end, as in Fig. 5, to prevent excessive loss due to eddy currents. Large coils are generally wound on forms and held in position on the cores by small brackets.

Magnet Calculations

The first essential in the design of an electromagnet is to determine the pull. Assume that it is desired to construct a pair of magnets, as in Fig. 1, which must have a combined pull of 50 lb. through a ½-in. air gap. The pull in the air gap decreases as the square of the distance, so that the magnets will have to be designed for a combined pull of 200 lb. for a total of one inch or ½ in. on each side. Assume a 25-cycle circuit and a core density of 30,000 lines of force to the square inch. The formulas for determining pull and the transpositions for determining the other factors are as follows:

$$P = \frac{B^2 \times A}{72,134,000}$$

$$A = \frac{72,134,000 \times P}{B^2}$$

$$B = \sqrt{\frac{P \times 72,134,000}{A}}$$

where,
P = Pull in pounds;
B = Magnetic density per square inch;
A = Area of core in square inches.

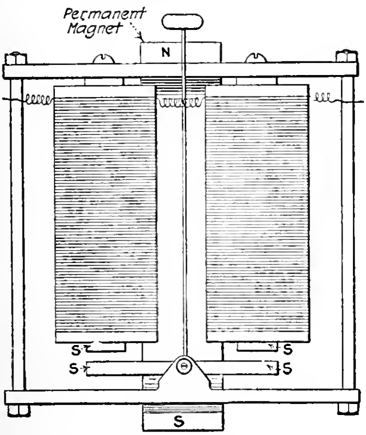


Fig. 4. Polarized Electromagnet

The pull is divided between the two magnets and therefore will be 100 lb. in each.

The area of the core will be:

$$A = \frac{72,134,000 \times 100}{30,000^2} = 8 \textit{ sq.in. (approximately)}$$

To allow for some losses, it will be best to make the core 9 sq.in., or 3 in. square.

The number of turns required will depend on the magnetic flux N which threads through the turns, the maximum value being expressed as follows:

$$N = B_{max} \times A$$

where B_{max} is the maximum value which the magnetic

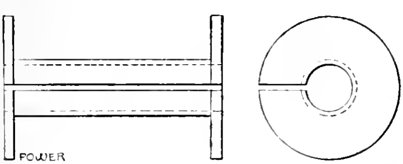


Fig. 5. Split Spool to Prevent Eddy Currents

density reaches during a cycle, and A is the cross-sectional area of the iron, in this case 9 sq.in. Hence,

$$N = 30,000 \times 9 = 270,000 \textit{ lines.}$$

Taking the induced electromotive force as equal and opposite to the line voltage,

$$E = \frac{4.44 \times N \times T \times n}{10^8}$$

where
N = Maximum value of the magnetic flux through the core;
T = Number of turns in the coil;
n = Frequency in cycles per second;
E = Impressed e.m.f.

Applying to the present example.

$$440 = \frac{4.44 \times 270,000 \times T \times 25}{10^8}$$

whence,

$$T = \frac{440 \times 10^8}{4.44 \times 270,000 \times 25} = 1468$$

Assume the core to be 9 in. long and the width of half the keeper and half the armature to equal 3 in. Also

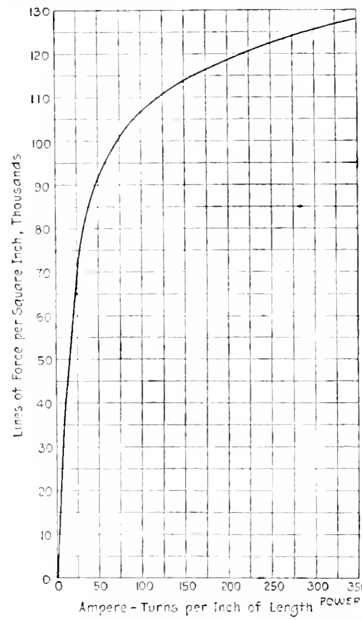


Fig. 6. Ampere-Turns vs. Lines of Force

let the distance from center to center of the cores be 11 in. Then the length of one-half the magnetic circuit, or the length per pole = 9 + 3 + 5½ + 5½ = 23 in.

From a permeability curve the permeability of soft iron at a density of 30,000 lines per square inch is found to be 1100 and that of air is always taken as one: therefore, it will require 1100 times as many ampere-turns per inch of length of the magnetic circuit for the air gap. From Fig. 6 it will be found that approximately 5.5 turns per inch of length of the magnetic circuit are required. Then the turns per coil for the iron will be 23 × 5.5 = 126½, and for each air gap of ½ in., 5.5 × 1100 × 0.5 = 3025, and 3025 + 126 = 3151 ampere-turns per spool.

As there are 1468 turns per spool, the current will be approximately two amperes. Allowing 2000 circ.mils per ampere, it will be found from a wire table that No. 14 B. & S. gage corresponds the nearest to the required size. The table shows that No. 14 wire has 13 turns to the inch;

and, allowing $8\frac{1}{2}$ in. as the length of the spool, the result is 13 × 8.5 or approximately 110.5 turns. Then 1468 ÷ 110.5 = 13+, the number of layers.

SINGLE COTTON-COVERED MAGNET WIRE DATA

B. & S. Gage	Turns per Inch	Layers per Inch
4	4.5	4.78
5	5.09	5.82
6	5.66	6.41
7	6.02	7.3
8	7.05	8
9	7.66	8.42
10	8.54	9.6
11	9.7	11
12	11.2	12.8
13	12	14
14	13	15.4
15	15.37	17.9
16	16.74	19.4
17	17.74	21.33
18	19.5	23
19	22.77	24.9
20	25.7	29.7
21	28.3	32.5
22	31	36
23	34.4	40.36
24	36.9	44.6
25	38	47
26	42	50.5
27	48	55.5
28	53.28	61.1
29	59	68
30	63.26	76.8

From the table it will also be found that there are 15.4 layers to the inch for No. 14 wire, so it will be necessary to allow 1½ in. for the depth of the winding, including the insulation between layers.

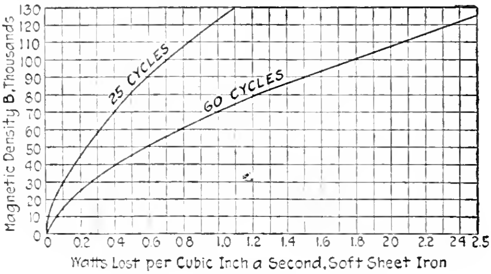


FIG. 7. HYSTERESIS CURVES

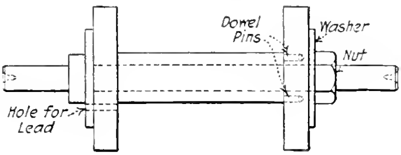


FIG. 8. FORM FOR WINDING COILS

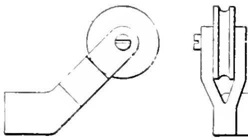


FIG. 9. GUIDE FOR WIRE

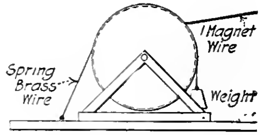


FIG. 10. METHOD OF PROVIDING PROPER TENSION

As the spool is square in cross-section, this will give each side a width of 3 in. or a perimeter of 12 in., and the mean perimeter of the coil is 18 in.

1468 × 18 ÷ 12 = 2202 *ft.*

is the length of wire per coil. The resistance of No. 14 wire is approximately 2.5 ohms per 1000 ft.; hence, there is approximately 12 ohms resistance for the two coils connected in series. Then the I^2R loss is 4 × 12 = 48 watts. The total core volume is 23 × 2 × 9 = 414 cu.in. From the hysteresis curves, Fig. 7, it will be seen that for 25 cycles the loss per cubic inch is 0.1 watt, so that the hysteresis loss will be 41.4, and the eddy current loss may be estimated as 10 watts. Then the total loss in watts will be 48 + 41.4 + 10 = 99.4 watts. The outside surface of the coils is 4 × 6 × 8.5 = 200 sq.in. per coil. As at least one square inch of coil surface must be allowed for each watt lost, it will be seen that the figures are well within the safe limit.

For winding spool magnets, small hand-driven machines can be purchased at low cost, but a lathe is more satisfactory. Fig. 8 shows a simple form for winding coils which have no spools. It consists of a wooden spindle and end turned from one piece and mounted on a steel arbor. It is secured by a flange attached to the arbor with a pin or setscrew. One end of the spool is removable and is held in place by a nut and dowel pins.

A guide for the wire is shown in Fig. 9, which is intended to be clamped in the tool post of the lathe. It consists simply of a grooved brass wheel free to revolve on a pin supported by a forged-iron holder. By moving the lathe rest backward and forward the wire can be wound evenly and quickly. It should be wound under tension, which may be provided as shown in Fig. 10.

Practically all wire reels have a groove on one side which will receive a wire to which a weight is attached, as shown. The tension can be made as great or as little as desired by varying the weight. If there is no groove in the reel, a flat band of sheet iron or steel can be substituted.

To secure the last turn of wire on the coil in position, a piece of webbing in the form of a loop is laid under the last five or six convolutions and the wire end is passed through it, after which it is drawn up tight. The coil is then slipped off the spool or form and given a wrapping of tape or webbing, after which it should be given a thorough coat of insulating paint. It is generally preferable to solder a piece of flexible conductor to the wire ends inside the coil.

Nipples—A nipple is a fitting made from tubular goods, and usually threaded on both ends. It is under 12 in. in length. Pipe over that length is referred to as cut pipe.

A close nipple has no shoulder and is about twice the length of a standard pipe thread.

A shoulder nipple has any length. It derives its name from the shoulder of pipe left between the two threads. A shoulder nipple is intermediate in length between a close and a short nipple.

A short nipple is slightly longer than the lengths of the two threads, being a trifle longer than a close nipple. Some unthreaded shoulder exists between the two threads.

A space nipple contains a shoulder between the two threads, and may be of any length allowing a shoulder.

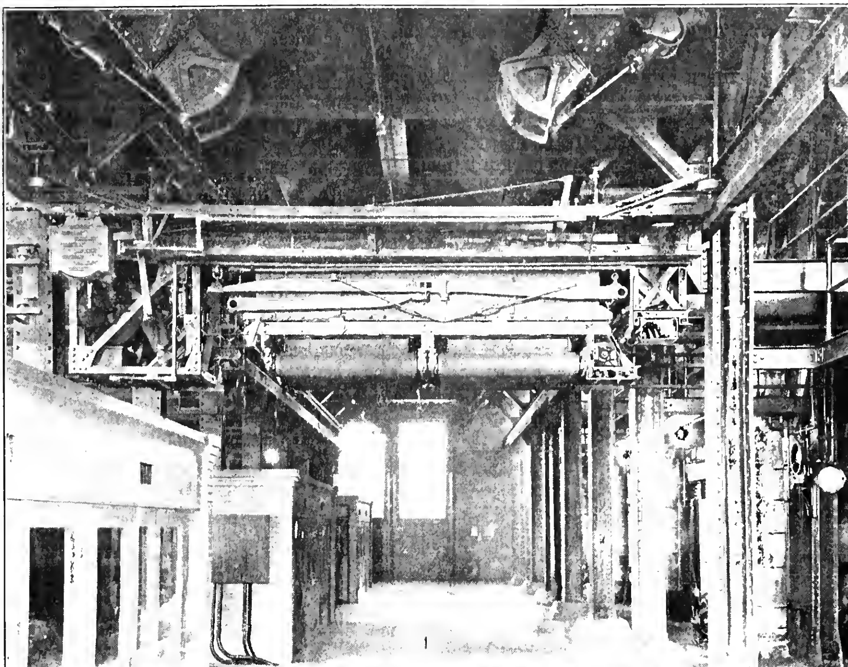
A sub-nipple is a substitute nipple, or, in other words, a short pipe with different styles of thread on its ends.

A swage nipple is a reducing nipple, having one end smaller than the other.

A long screw nipple is made up of a short length of pipe; one end has a standard thread, the other is threaded far enough to allow a coupling and lock-nut to be turned by hand without overlapping the pipe end. It is an advantage when making a connection, or for connecting pipes in place.

Coal-Weighing Larries

The Cleveland municipal electric-light plant uses two Brownhoist coal-weighing larries to transport the coal from the bin to the stokers and weigh each load (Fig. 1). The plant is equipped with a large coal bin arranged with four rows of hoppers, each fitted with a Brownhoist air-operated gate, and each separately controlled by an air valve located along the crane runway within reach of the larry operator when the larry is stopped beneath the gate. The air cylinder is swiveled so that it will adjust itself to the different positions of the piston while the gate is in the act of opening and closing.



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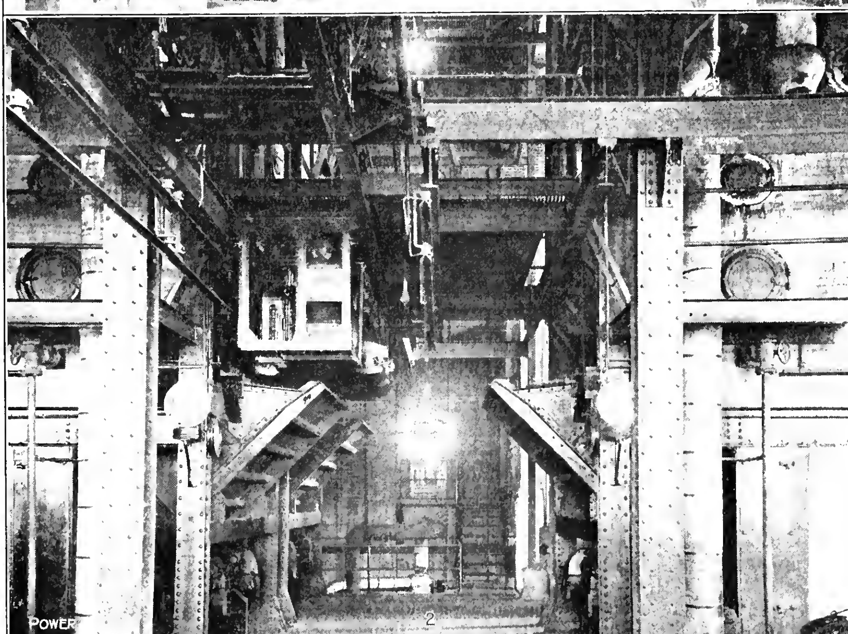

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Each larry operates with a transfer crane which travels along a runway beneath two rows of the gates. The larries reach the other two rows of gates by individual tracks. The transfer crane is operated from the larry. The operator brings the transfer crane into alignment with the tracks running to the stokers or to the farthest coal gates and the larry runs off the crane onto these tracks after a locking device is set to keep the crane in alignment with the tracks. Fig. 2 shows the larry delivering coal to the stokers. Each electrically operated larry is of two-ton capacity. Two gates are provided through which the coal flows onto a belt which throws it into the hoppers.

The larries and cranes are equipped with brakes, and all open ends on the tracks are provided with safety stops to prevent the larries running off. Each larry is equipped with scales, with the scale beam in the operator's cab. The operator keeps a record of all coal delivered to the stokers.

The Wages of Engineers

By Earl Pagett

Much has been written about the compensation received by engineers. As data on the salary drawn by engineers are noticeably lacking, the writer set out to collect the facts from the men themselves by a letter sent to engineers in widely separated sections of the United States. Of the seventy-five letters sent out, many came back and a number were not answered. It is regrettable that a greater number of places could not be heard from.

The following table shows the data as collected:

Place	Size of Plant, Hp	No. of Men Chief	No. of Men Ass't	Hr. per Week		Salary per Week Chief	Salary per Week Ass't
Cambridge, Mass.	25,000	1	4		56	$45 00	$26 50
	600	1	3		56	40 00	25 00
	400	1	3		56	35 00	25 00
	300	1	3		56	31 25	18 00
	500	1	1		60	35 00	23 00
				Chief	Ass't		
Baltimore, Md.	1,000	1	1	66		25 00	17 50
	600	1	2	54	72	30 75	17 50
	400	1	1	66	78	25 00	19 50
	400	1	2	54	72	25 00	17 50
	800	1	2	54	72	25 00	18 25
Hyattsville, Md.	700	1	3	56	56	34 60	23 00
	700	1	3	56	56	38 45	21 00
	450	1	2	56	56	30 75	20.75
	100f oil	1	0	56	72	23 00	
	100	1	0	70	84	23 00	
						Salary per Month	
Clay Center, Ohio.	5,000	1	2	70	84	$125	$85
	not stated	1	1	84	84	100	96
	700	1	1	84	84	75	70
Laramie, Wyo.	700	1	4	70	70	100	95
Lisbon, Ohio.	12,000	1	3	56	56	100	80
	1,000	1	3	56	56	110	80
	10,000	1	3	56	56	125	90
	6,000	1	2	84	84	90	80
Louisville, Ky.	15,000	1	2	84	84	160	125
	1,200	1	3	48	48	150	78
	300	1	3	56	56	100	90
	300	1	1	60	60	108	78
	100	1	1	72	72	108	65
Exeter, Neb.	225	1	1	54	54	90	70
	250	1	1	54	54	100	70

The standard rate for the mining districts of the Southwest does not vary greatly over a wide range of plant size. Chief engineers get from $150 to $200 a month, sometimes including house, light and water. Watch engineers receive from $125 to $150 a month; eight hours is considered a watch and thirty and thirty-one days a month. No reports on special plants were received.

Memphis, Tenn.: No report on special plants. The correspondent states that chief engineers average about $125 and assistants about $75 a month.

Foxboro, Mass.: The wages in this vicinity will average as follows:

	Per Week
First-class engineers	$23 to $30
Second-class engineers	18 to 23
Third-class engineers	15 to 21
Firemen	14 to 17
Hours worked will average	55 to 60

Framingham, Mass.: In plants of from 1000 to 5000 kw. three or four men are employed, working in eight-hour shifts, the chief sometimes standing a watch. Chief engineers receive from $25 to $35 per week and assistants from $18 to $25 per week.

In manufacturing plants of from 1000 to 2000 hp., usually one chief and three operating men are employed in eight-hour shifts. The chiefs get about $30 per week and the assistants from $18 to $24.

In smaller manufacturing plants of from 100 to 500 hp., one engineer and a day and a night fireman are employed. The engineer works 60 hours per week, spends from two to five hours at the plant on Sundays, and receives from $18 to $26 per week. Plants smaller than this pay from $15 to $18 per week of about 60 hours.

Large brewery plants in this vicinity pay about $35 per week for the chief engineer and $21 to $25 for the assistants; engineers work in eight-hour shifts.

South Chicago, Ill.: Information on one plant only. The men work six 12-hour shifts and change every week. First assistants get $4 per day, second assistants $3.50 and third, $3; oilers and stokers, $2.50 per day; chief engineer's salary not given.

Norman, Okla.: Plant of 250 hp., one day and one night engineer; 84 hours per week with $100 and $80 per month respectively. Pumping plant, one engineer at $1200 per year. Plant with three boilers and one 125-kw. generating set; one chief and two assistants on eight-hour shifts; chief receives $1000 a year, assistants $70 to $75 a month. Plant of 150 hp.; one chief, who is also superintendent of machinery, at $1200 per year.

New Orleans, La.: Chief engineers of ice and cold-storage plants, $100 to $200 per month, subject to call at any hour; assistants, $75 to $85 a month, 84 hours a week. No report on other plants.

Wichita, Kan.: Only one plant reported; 8750-kw.; one chief engineer and three assistants, each working 56 hours per week. The chief gets $125 a month and the assistants $75.

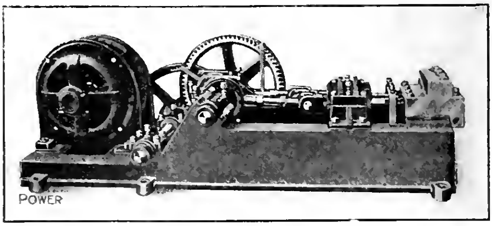
Coffeyville, Kan.: Plant of 900 kw., one chief engineer and two assistants on eight-hour shifts. The chief gets $100, assistants $75 per month. Plant of 400 kw.; one chief engineer, three assistants on nine-hour shifts. The chief gets $150 and the assistants $75 per month. Plant of 700 hp.; one chief working 70 to 77 hours per week at $95 a month. Plant of 150 hp.; one day and one night engineer on 12-hour shifts; day man gets $3 and the night man $2.50 per day. The day man washes the boilers on Sundays. Plant of 300 hp.; one day engineer, working 84 hours a week at $100 a month. The watchman cares for the plant at night.

There seems to be a wide variation in the wages paid in similar plants. Take the plant of 600 hp. in the vicinity of Cambridge, Mass.; it pays the chief engineer $160 a month, working 56 hours a week, while in the vicinity of Clay Center, Ohio, a plant of 500 kw. pays the chief engineer $75 a month for 84 hours a week.

It would seem that if it is worth $160 a month to run a plant in one place, it should be worth at least that much to run a similar plant almost any place.

Watson-Stillman Triplex Hydraulic Pump

The Watson-Stillman Co., 50 Church St., New York City, has added to its line a new type of motor-driven



Triplex Hydraulic Pump, Motor Driven

geared, triplex, single-acting pump. While primarily designed to meet the severe demands of tunnel service, it will be equally suitable for other conditions.

To secure compactness, rigidity and alignment of the working parts when under severe service, the motor is mounted on an extension of the heavy cast-iron base. The driving shaft and bearings are large and are provided with lubricating cups. The gears are of the heavy cut-tooth type. The drive from the shaft is by eccentrics set at 120 deg. cast in one piece and keyed with one key to the driving shaft. The eccentric straps are heavy.

The plungers are of tool steel and are guided in a cross-head guide, which is keyed and bolted to the base.

The pump body is a steel forging fitted with bronze valves and bonnets. All passageways are made large to reduce the friction of the water to a minimum. The pump, shown herewith, is operated by a 10-hp. motor running at 600 r.p.m., and delivers 100 cu.in. of water per minute at 3500 lb. pressure, with a crankshaft speed of 100 r.p.m. Other sizes of the pump are built to suit operating conditions.

Installation and Care of Fire-Protection Apparatus

By J. O. Benefiel

Usually, such apparatus is installed under the supervision of an insurance company, but it often happens that additional buildings are erected requiring automatic sprinklers, and the engineer should be able to plan and supervise the extensions satisfactorily, thus saving his employers considerable expense.

One thing he should avoid is getting too many sprinklers on one branch line. The distance from the wall to the first sprinkler should not be more than half the distance between sprinklers in the same direction. Under a pitch roof one line of sprinklers should be in the peak. Splash plates should not be less than three nor more than ten inches from joists or ceilings. All stairways, closets and odd corners should be looked after.

LOCATION AND SPACING OF SPRINKLERS (FROM THE RULES AND REGULATIONS OF THE ASSOCIATED FACTORY MUTUAL INSURANCE CO.)

One Row of Automatics Placed Midway between Beams in Each Bay		Water Pressure at Highest Sprinkler Exceeding 20 Lb.		Less Than 20 Lb.	
		Medium Hazard	Special Hazard	Medium Hazard	Special Hazard
In 12-ft. bays	Sprinklers:	8 ft. apart	7 ft. apart	7 ft. apart	6 ft. apart
In 11-ft. bays	Sprinklers:	9	8	8	7
In 10-ft. bays	Sprinklers:	10	9	9	8
In 9-ft. bays	Sprinklers:	11	10	10	9
In 8-ft. bays	Sprinklers:	12	11	11	10
In 7-ft. bays	Sprinklers:	12	11	11	10
In 6-ft. bays	Sprinklers:	12	11	11	10

The terms "medium" and "special hazard," in the table, relate to the contents or occupancy of each room. Especially hazardous places are picker rooms, sawing departments of wood-working plants and varnish rooms.

The following tabulation gives the maximum number of sprinklers to be supplied by the sizes of pipe given:

Size of Pipe, In.	No. of Sprinklers	Size of Pipe, In.	No. of Sprinklers
¾	1	3	36
1	2	3½	55
1¼	3	4	80
1½	5	4½	110
2	10	5	140
2½	20	6	200

Supporting the branch pipes by hangers in rooms where there is much heat or steam is a serious problem. Another annoyance is leakage around the valve stems.

The swing checks on the inlet from city mains and the discharge from the fire pump sometimes stick open when the spindle on which the check swings is iron and corrodes. All moving valve parts should be made of brass.

In rooms where certain processes are carried on, the sprinklers should be taken off and cleaned whenever they become coated with deposits.

During the regular overhauling in a certain plant the disks of the 2-in. drain valves are taken out, cleaned, and a ring of gasket rubber is put on the disk to prevent a leakage which would cause a loss of the water seal on top of the dry valve.

To those not acquainted with the valves it is explained that the upper (sprinkler) side of these valves has about five times the area exposed to the air pressure to hold it shut to one on the lower side subjected to water pressure. About 35 lb. of air is usually carried to balance 100 lb. water pressure. When a sprinkler head acts, the air pressure is reduced and the water-supply valve opens. The system then fills with water. After being in action it is necessary to again put the system in order. All the

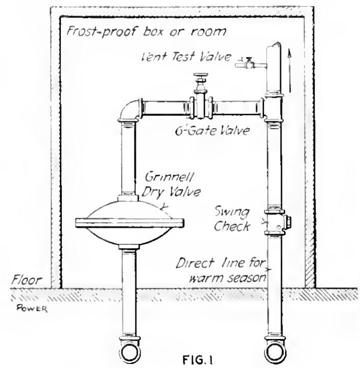


FIG. 1

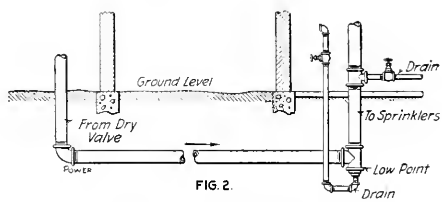


FIG. 2.

Underground Section of Line

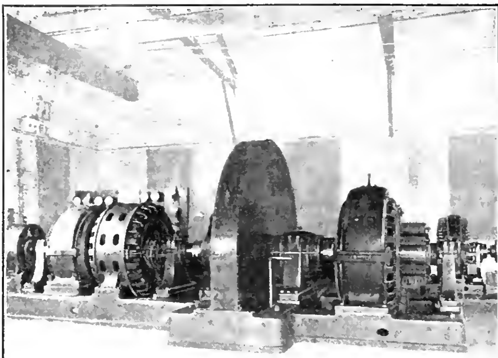
drains are opened to let the water out to the test valve above the tee shown, Fig. 1.

All the drains are then closed and from forty to fifty pounds of air pressure is put on the system. One man goes around opening the drains, one at a time, until they show no water. The air pressure is then brought up to about thirty-five pounds and the valve in the yard is opened to let the water pressure against the under side of the dry valve. The drains should be opened about twice a week for two or three weeks to make sure the system is free of water.

If the building is warm during the day and cold at nights and on Sunday, an allowance must be made for a loss of pressure due to the air contracting in the pipes.

Fig. 2 shows a drop underground to another building. The draining of the underground section was a problem, there being no sewer. It was done by bringing the drain to the surface, as shown, and blowing the water out by air. It has worked successfully for years and has but one drawback—so much talking must be done to convince each new inspector that it works.

Interesting Power-Plant Apparatus



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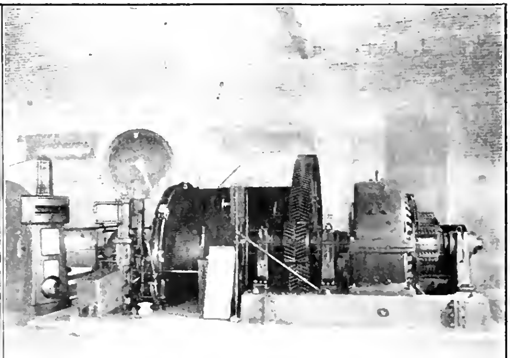

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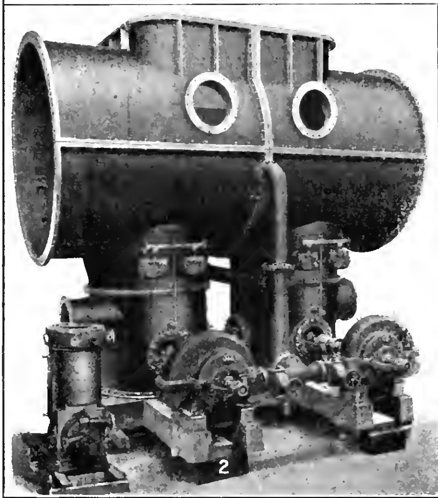

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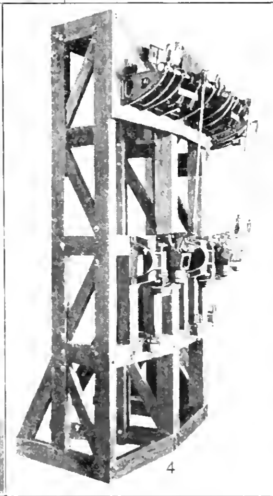

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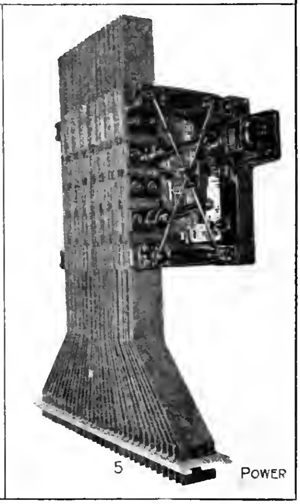

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Fig. 1 shows a Wellman-Seaver-Morgan Co. duplex motor-generator flywheel set consisting of a 350-hp. motor driving one 400-kw. and one 200-kw. direct-current, 550-volt generator running at 720 r.p.m. At one end of the shaft there is attached a direct-current exciting unit. The flywheel weighs 25,000 lb.

This machine, which is used by the Cleveland Cliffs Iron Co., acts as a balancing set and furnishes direct-current to a main ore hoist and to a man-and-timber hoist. Fig. 3 is a geared hoist with a single drum for hoisting men and timber in a single 1300-ft. compartment shaft, the counterbalance being obtained by the use of counterweights. The machine is geared to produce a hoisting speed of 1000 ft. per min.

The drum is 96 in. diameter by 84 in. face, and is grooved for a $1\frac{1}{4}$-in. rope. A 96-in. diameter band brake is on one end of the drum. The double-acting brake is applied by gravity and is released by means of a combined air and cataract cylinder. The gears are of the herringbone or helical type. The electrical equipment consists of a 500-volt, 200-hp. direct-current motor running at 250 r.p.m. and receiving its current from the duplex motor-generator set, Fig. 1.

Fig. 2 is a large jet condenser with a small jet condenser in the foreground. The large unit is in use at the Westport plant of the Consolidated Gas, Electric Light & Power Co., Baltimore, Md., with a 15,000-kw. turbo-generator. This condenser takes care of 200,000 lb. of steam per hour to a $28\frac{1}{2}$-in. vacuum with 70 deg. F. injection water.

The small condenser shown is used with turbines up to 300 kw. capacity. This particular unit takes care of a low-pressure turbine of 100 kw. capacity.

In both condensers the same general idea is worked out; viz., the air- and water-removal pumps being on the one shaft, either turbine or motor driven, the removal pump being submerged in the tank base of the condenser. Both units have substantially the same water distribution and are of the parallel-flow design.

Fig. 4 is a 12,000-amp., 600-volt circuit-breaker, the largest capacity alternating-current circuit-breaker in the world. It is in the Wood Worsted Mills, Lawrence, Mass., the largest worsted mills known.

Fig. 5 illustrates a 40,000-amp., motor-operated switch for electric furnace. The output of the furnace is either 20,000 amp. with a potential of 40 volts, or 40,000 amp. with a potential of 20 volts. The weight of the switch is $7193\frac{1}{2}$ lb. In the construction of this switch 5268 lb. of copper was used, over $2\frac{1}{2}$ tons; 871 lb. of composition metal; 681 lb. of cast iron; 342 lb. of steel and $31\frac{1}{2}$ lb. of mica. This switch was manufactured by the General Electric Co., Schenectady, N. Y., as was the 600-volt circuit-breaker.

Editorials

The Year's Review

In 1913 the word "large" best defined the tendencies of development, and the impetus gained in this period has carried over into the year just past. Notwithstanding the general depression in business, installations were made in which some of the equipment holds first place in size or capacity. Long ago the advantages of concentration were appreciated and the constantly growing demands have urged the manufacturer to greater efforts. Each year something bigger than ever before makes its appearance and apparently only raises the horizon for the particular field concerned.

In looking over the files for the year the first large device to attract attention is a Mesta triple staggered-tooth spur gear, 22 ft. 8 in. in diameter, having a 38-in. face and 154 teeth spaced on 5½-in. circular pitch. It was built to drive a sheet mill of the Inland Steel Co., and at a speed of 2000 ft. per min. the gear transmits 1600 hp.

For the Woodward Iron Co. two horizontal cross-compound Mesta blowing engines, 48 and 84 by 60 in., were installed. A notable feature was the building of one engine in 38 days and the completion of both in 59 days. The Nichols Copper Co., Long Island City, has the largest Keeler water-tube boiler ever built. The boiler is rated at 1280 hp. and has a little more than half the capacity of the Stirling boilers now being installed at the new Connors Creek station of the Detroit Edison. It will be remembered that these boilers are rated at 2350 boiler-horsepower, and by forcing are capable of carrying continuously the enormous load of 13,300 kw. Normally, they are designed to care for 10,000 kw.

In cooling towers there have been three large installations: one a twin Wheeler-Barnard forced-draft tower for the American Hardware Co., New Britain, Conn., capable of cooling 132,000 gal. of water per hour from 100 to 80 deg. F.; a battery of towers of the same type to cool 600,000 gal. of water per hour for the Texas Power Co., Waco, and a Mitchell-Tappen atmospheric tower capable of cooling 120,000 gal. per hour through the range previously given. The tower last mentioned was installed for the main power house of the South West Missouri Railroad Co., at Webb City, Mo.

A notable pump installation was made for the Plaquemine & Jefferson Drainage District of Louisiana, consisting of four 76-in. and one 48-in. centrifugal pumps built by the Southwark Foundry & Machine Co. The larger pumps each have a capacity of 168,000 gal. per min. (over 10,000,000 gal. per hr.), at 1-ft. head and 40,000 gal. per min. against a head of 13 ft., and are used to pump water back over the levee into the Mississippi River. The 100-million gal. De Laval centrifugal pump recently installed at Pittsburgh has a 48-in. outlet, but it must raise the water against a total head of 56 ft. Another interesting installation is the first large American-built Humphrey gas pump which is to be used for irrigation purposes near Del Rio, Texas. The cylinder is 66 in. in diameter and is supplied with gas by a 300-hp. Akerlund down-draft producer capable of gasifying either soft coal or mesquite wood.

The Alabama Power Co. has recently installed the first of four 17,500-hp. generating units at its hydro-electric station on the Coosa River. The turbine is the largest of the single-runner type in operation. To the Brooklyn Edison must be credited the largest single-cylinder steam turbine. It is rated at 22,000 kw. and with a moderate temperature rise it is expected to carry 25,000 kw.

Recently the first car containing parts of the mammoth direct-current generators for the Ford plant in Detroit left the works of the Crocker-Wheeler Co. Each of the four machines is to have a normal capacity of 3750 kw. and will weigh 105 tons. The field frame is 24 ft. high and 26 ft. wide across the supporting feet. The armature is 16 ft. in diameter and weighs 87,000 lb. As this dimension exceeded the limits for track clearance the assembling of the armature parts and the winding must be done in Detroit.

Another event worth noting in the electrical field is the completion of the longest transmission line by the Southern Sierras Power Co. It extends 400 miles from the generating station to the most distant customer, but the main straight-away transmission is not as long as that of the Big Creek system.

Credit for the largest Diesel engine built in this country to date belongs to the Lyons Atlas Co., Indianapolis. It has four 24x30-in. cylinders, which will develop normally 600 hp. and a maximum of 690 hp. driving a two-stage turbine pump of 15 million gal. capacity against a head of 200 ft. The unit will be used by the Hawaiian Commercial & Sugar Co. for irrigation purposes.

Valves for steam headers which weigh 3600 and 3900 lb., respectively, are not common. In fact, the Nelson valves of the above weights recently furnished the New York Edison Co. are claimed to be the largest steel gate valves for superheated steam yet installed. When open they measure 9 ft. 1 in. from the bottom of the body to the top of the stem. The valves are to be mounted in 18-in. steam leads, carrying steam under 200 lb. pressure and 150 deg. superheat.

Steam Turbines

Of the various large turbines building for Chicago, New York, Philadelphia and elsewhere, perhaps the most interesting is the 35,000-kw. unit for the Philadelphia Electric Co., as it is the largest in the world by 5000 kw. The prime mover is a thirteen-stage horizontal Curtis turbine 63 ft. 2 in. long over all, 21 ft. 7 in. wide and 15 ft. 10 in. high. The weight of the unit is 600 tons. It will receive steam at 215 lb. pressure and 150 deg. superheat and exhaust against an absolute pressure of 1.5 in. of mercury. At the most economical load, 25,000 kw., it is expected to develop a kilowatt-hour on 11.9 lb. of steam. At the full rated load of 35,000 kw. the water rate increases to 12.6 lb. per unit. With a better vacuum the steam consumption will be lowered slightly. The condenser for this immense unit is naturally the largest in the field. It is of the center-flow surface type containing 50,000 sq.ft. of surface in 1-in. tubes. This reduces to 1.43 sq.ft. per kilowatt of turbine rating, which may be compared to an average of 3 sq.ft. a few years ago. That injection water is supplied through a 48-in. pipe will give some indication of the quantity required. The auxiliaries are all turbine-driven centrifugal units, and the air pumps are the Le Blanc type. The generator delivers three-phase 60-cycle currents at 13,200 volts. The speed is 1200 r.p.m. The station is to contain also a 30,000-kw. unit of the same type which will deliver 25-cycle current with the same expenditure of steam at the most economical load, 22,500 kw. The speed will be 1500 r.p.m.

When the above water rate is compared to the guarantee for the 25,000-kw. Parsons turbine at Fisk Station, of 11.25 lb. per kw.-hr. against a back pressure of 1 in. of mercury, it will be seen that there is little if any difference in economy between the two machines. It may be of interest to state that this English unit is now in satisfactory operation. The troubles usually encountered when starting a machine of a type new to the station, and other troubles due to damaged insulation, have been overcome.

As previously stated in these columns, this unit is of the two-cylinder tandem type; the Brooklyn Gold St. turbine has but a single cylinder, while the 30,000-kw. Interborough turbines have two cylinders arranged cross-compound and operating at different speeds. Several advantages are claimed for the compound units such as a smaller temperature range in each cylinder, the possibility of separating the moisture midway in the expansion of the steam, smaller cylinder structure and the reduction of stress set up by wide temperature ranges. In the single-cylinder turbine this is offset by a machine which takes about three-fifths the floor space occupied by the tandem compound and a still lower fraction of the space taken by the cross-compound. The water rates do not vary appreciably. The action of the Brooklyn turbine in practice will no doubt help to determine the limits of a single cylinder.

In this same turbine the stationary blading for the high- and intermediate-pressure sections is not fastened to the casing but is mounted on cylinders set into it. This practice is being followed in other large turbines as it has been found desirable from the standpoint of convenience and strength. An increase in the speed of these large units is also a point of interest. The earlier of the large turbines were designed for 750 r.p.m.; the Brooklyn unit makes 1500 turns per minute, and some 20,000-kv.-a. turbines now being built for the Public Service Corporation of New Jersey are to run at 1800 r.p.m.

A serious difficulty tending to limit the capacity of these great machines is the problem of utilizing effectively the immense volumes of steam in the lower stages. The struggle to obtain greater peripheral velocity for the final stages and greater section through them so as to maintain the most efficient ratio between steam and blade velocity has resulted in a number of suggestions such as a considerable increase in the diameter of the final elements, a combination of velocity, pressure-impulse and reaction stages and other arrangements tending toward the same end, as discussed quite recently in these pages.

Engine Progress

For several years the tendency has been toward higher speeds and consequently engines of less weight which require less excavation and concrete and give more room for purposes other than power generation. By the use of higher pressures and some superheat, water rates have been lowered, although the longevity and low upkeep of the Corliss have been sacrificed to some extent. The reduction in initial cylinder condensation by the adoption of the una-flow principle has boosted the economy of condensing engines. With pressures ranging from 300 to 500 lb. there are great possibilities for the above type. Already results obtained from one cylinder equal those from the average compound, and the ultimate goal is an economy approaching that of the Diesel engine.

In this connection it may be of interest to state that the year has seen the first una-flow engine built in America under the patents of Professor Stumpf and the personal supervision of his representative. A 15x16-in. engine designed to carry 100 kw. and running at 250 r.p.m. under a steam pressure of 145 lb., a superheat of 88 deg. and a vacuum of 25½ in. developed an indicated horsepower-hour on 12.5 lb. of steam. The lowest noncondensing rate with steam superheated 130 deg. was 16.8 lb. and with saturated steam, 20.4 lb. It is evident that the una-flow is primarily intended to operate condensing. Another design of una-flow engine has been perfected by the Skinner Engine Co. with practically the same noncondensing steam rates, and the Nordberg Co. has produced a una-flow engine with poppet valves to supersede, for high pressures and superheats, its previous design employing Corliss valves. The same company has also improved its poppet-valve engine by locating the valve seats in the heads and operating the valves mechanically instead of depending on a spring for the return movement.

The first Buckeye-mobile in commercial service is a feature of the year. This particular unit is rated at 115 hp. and is directly coupled to a 75-kw. alternator at the works of the International Cork Co., Greenpoint, L. I. It occupies a floor space 17 ft. 10 in. long by 7 ft. 6 in. wide. From the base to the top of the flywheels the unit stands 9 ft. high. In its shop test the engine, which is compounded, developed a steam rate of 13.3 lb. per i.hp.-hr. on 1.33 lb. of coal. The boiler pressure was 210 lb. and the superheat 171 deg.

Boilers

The practice of forcing boilers for the peak load to double and, in some cases, triple their rating is becoming more firmly established. Where formerly it was customary to provide a boiler-horsepower for every kilowatt of generating capacity, a ratio of 1 to 4 is now common in the larger stations. Lower water rates, of course, help in this direction. In the new generating plant of the United Electric Light & Power Co., of New York, commonly known as the 201st St. Station, which was officially put in commission on Jan. 31, one boiler-horsepower is expected to care for 4.7 kw. At Waterside No. 2, the ratio of boiler-horsepower actually used to installed generator capacity is 1 to 4.2 and in emergencies at Delray one boiler-horsepower will supply 5.65 kw. This necessitates a more extended use of forced draft, although in Boston a natural-draft plant with some cheap means, such as steam jets, of materially increasing the draft during peak loads, is considered the ideal installation.

The amount above normal rating at which a boiler can be safely operated depends largely upon the scale-forming and suspended matter in the feed-water. In quite a number of the larger stations where boilers are forced to several times their ratings, the use of distilled water is being considered. The cost would not be great, as the make-up in a "tight" plant is only a small percentage of the feed. Some doubts as to the corrosive effect of distilled water are prevalent, but its use for years in marine plants has failed to reveal any serious trouble.

A startling suggestion brought forward this year by W. L. R. Emmet, of the General Electric Co., is the use of mercury as a working fluid for heat engines. The project has taken more definite form than a mere proposal, as experimental work has been conducted for some time and the installation of a 100-hp. unit at Schenectady was completed some nine months ago. A mercury boiler supplies vapor to a turbine. The latter exhausts to a condensing boiler which generates steam for another turbine on the same shaft. The mercury is, of course, returned to its respective boiler. The advantage of using mercury lies in its ability to utilize much higher temperatures without excessive pressures. At atmospheric pressure mercury boils at 677 deg. F. and condenses in a 28-in. vacuum at 455 deg. The density of its vapor is another advantage permitting in a turbine the use of much shorter blading in the low-pressure stages. Comparing the system to the ordinary steam plant, Mr. Emmet estimates a gain of 66 per cent. in delivered power at an additional fuel expenditure of 15 per cent. About $10 worth of this new medium will be needed per kilowatt of mercury turbine.

In Europe, high-voltage, alternating-current electric boilers have been in use for a number of years. These boilers take the primary current and may be used to generate steam for heating or commercial purposes, to keep the water hot in boilers of a steam reserve plant or to maintain reserve water units in operation, which may be switched into service on the line at a moment's notice. The first plant on this side of the Atlantic was installed this year in eastern Canada. It consists of two single units of 750 kw. each, operating on 2400-volt, three-phase current to generate steam of 125 lb. pressure for heating a cotton mill during night hours. It is estimated that one kilowatt-hour will produce about three pounds of saturated steam at pressures up to 125 lb.

A new sectional water-tube boiler in which one large circulating pipe conveys all of the water from each drum to the bottom of the header sections has been perfected by A. Venning, Preston, Ont. T. T. Parker, New York, has patented a cross-drum water-tube boiler with several novel features, and quite recently the possibilities of the high-pressure Winslow boiler have been brought to the attention of the engineering fraternity.

In locomotive practice in the past year the Crawford stoker has shown wonderful possibilities for heavy freight and transfer as well as fast passenger service. Rates of combustion as high as 200 lb. of coal per square foot of grate per hour have been obtained.

Marine Tendencies

Relative to development in the marine field the Talbot and the Niclausse boilers have been improved with a view to bettering the circulation and as a natural consequence the efficiency. The new Ward wrought-steel, water-tube boiler for marine purposes is also a product of the year.

On Feb. 26 the "Britannic" was launched. In spite of the war, the White Star Line expects to put this 50,000-ton liner in service in 1915. She is 900 ft. long, which may be compared to 882 ft. 9 in. for her predecessor, the "Olympic." The extreme breadth is 94 ft. and the displacement at a load draft of 34 ft. 7 in. is 53,000 tons. The displacement of the "Olympic" when drawing 34 ft. 6 in. is 3000 tons less. Chief interest centers in her machinery. Three-screw propulsion is effected by four-cylinder, triple-expansion engines, 54, 84, 97 and 97 by 75 in., on the wing screws and a low-pressure turbine on the center screw. The latter will receive steam at about nine pounds absolute pressure and exhaust into condensers at one pound absolute. At 165 r.p.m. the turbine will develop more than 16,000 hp. The great advantage of such equipment is that the machinery can be worked at reduced power with practically the same efficiency as at full load.

The annual report of Lloyd's Register, recently issued for the year ending June 30, 1914, calls attention to the increasing use of steam turbines, and especially those which are geared to the propeller. At present there are 23 vessels now being built under Lloyd's classification in which geared turbines are to be fitted, six vessels which will use direct turbine drive and six which will have the three-screw combination installed in the "Britannic." Employing the reduction gear allows both turbine and propeller to be driven at speeds most efficient for each. The U. S. Collier "Neptune" has shown the adaptability of reduction gears, and with the higher turbine and lower propeller speeds suggested by the original trials, good results are expected.

In the U. S. Collier "Jupiter" electric drive was installed. In the year and a half in which she has been in commission she has steamed about 14,000 miles and has been thoroughly tested under all conditions of service. The speed of the nine-stage Curtis turbine is 1990 r.p.m. and of the two induction motors driving the propellers, 110 r.p.m. In showing an economy from 20 to 25 per cent. greater than her sister ships, the boat has more than vindicated the claims of the designers. As a result the Navy Department has decided to equip the battleship "California" with electric drive.

Another feature mentioned in the report was the increasing use of large Diesel-engine motor ships. At present 27 vessels holding Lloyd's classification have an aggregate of 50,000 i.hp. in Diesel engines, and there are twenty more now building.

Coal and Smoke

For a long series of years the coal produced in this country has doubled every decade. For the past year the estimated production is 550 million tons, or about 5 tons per capita. At this alarming rate, increasing with each succeeding year, the supply will be exhausted at no distant date. Conservation of the supply is thus becoming more urgent. While the cheapness of the fuel has discouraged concentrated effort, some progress has been made. Classification of the coal is finding a constantly widening field of application, the obstacles common to the burning of powdered coal are being overcome and the washing and sizing of Western coals is resulting in a decided gain. Such plants as the one installed this year at Hauto, Penn., utilize what was formerly a waste at the mines, and in supplying the surrounding territory with electric energy conserve the supply of coal worth shipping.

Considerable progress has also been made in smoke suppression. Most of the large cities in the country are now actively engaged in abating this nuisance, although there is a general hesitancy in appropriating sufficient funds for the purpose. Pittsburgh in particular has become more active in the past year. The city is the largest consumer of bituminous coal in the world and its annual soot fall has reached the enormous figure of 1031 tons per square mile. Truly the opportunities for "cleaning up" are great, and with the incentive awakened surprising results may be expected.

Europe is also awaking to the possibilities of smoke prevention. Twenty-four English and Scotch cities are making soot observations with standardized apparatus and methods. Educational classes for engineers and firemen have been started with a view to teaching them improved methods of burning coal. Progress is necessarily slow, because of the limited powers conferred by existing laws and because societies for the suppression of smoke are dependent upon membership fees and donations for the funds required to carry on the work. Finland is active in smoke abatement and Hamburg has a smoke-prevention society made up of manufacturers to the number of 473. The society is a voluntary association of large consumers of fuel bound together by the common interest of reducing smoke and bettering the efficiency of their boilers.

Electrical Advancement

Oct. 21 last commemorated the thirty-fifth anniversary of the invention of the incandescent lamp. On the above date in 1879 Thomas A. Edison first successfully made a carbon filament glow. It was the beginning of interior electric lighting in small units, the arc having preceded the incandescent by a few years, although to a limited extent.

Perhaps the most notable development in switchboards was that for the control of the Panama Canal Locks, which was completed during the early part of the year. The 35,000-kw. generator for the Philadelphia Electric Co. has already been mentioned. Among the more special apparatus is the Kapp phase advancer. It consists of three small, direct-current motors connected in circuit with the rotor of an induction motor. The small machines set up an electromotive force in opposition to that produced by the slip of the rotor and in this way increase the power factor to unity or above.

In England and on the Continent considerable attention has been given to this problem of phase advancing. In the former country an installation in connection with a 330-hp. induction motor has been made quite recently. A new method of self-synchronizing rotary converters has been developed and is being extensively adopted by British manufacturers. The General Electric Co. has perfected a revolving compensator with one collector ring for obtaining the neutral connection with three-wire operation. It is to supersede the familiar separate stationary compensator and two-collector-ring arrangement.

The use of synchronous condensers of large capacity for voltage regulation as well as power-factor correction has been introduced in connection with the Big Creek development of the Pacific Light & Power Corporation. It may be recalled that this company employs the highest transmission voltage yet attempted, 150,000 volts. Outdoor substations continue to grow in popularity and the practice of washing air for cooling electrical apparatus has become more general during the past year. Improvements have been made in oil switches for meeting the general tendency toward higher voltages, and more satisfactory designs of power-limiting reactances have been developed. Equally important with the development of new devices is a set of safety rules governing the use of electrical apparatus, which has been compiled during the past year by the Bureau of Standards. A radical revision of the old rules was made in the basis of rating machinery. From a thermal standpoint a rating no longer is established by a standard rise in temperature under prescribed conditions of load but the hottest spot in the insulation is made the deciding factor. There is no provision for overloads causing a temperature higher than specified. The owner must take all risks if he desires to exceed the limit.

Gas and Oil Engines

In the gas-power field there has been little new in producer work or in gas-engine developments. Ehrhardt and Sehmer of Saarbrucken, Germany, have increased the power, and incidentally the efficiency, of their engines by thoroughly scavenging the burnt gases and introducing the fresh charge under pressure. A blower driven by a motor or by a turbine supplied with steam from a waste-heat boiler delivers the air and gas under a pressure of 10 to 15 lb. Due to the lower temperature from scavenging and to the pressure, a heavier charge and a better mixture of live gas are obtained. The effect is to raise the mean effective pressure and to improve conditions generally.

A distinctive advance has been made in the recovery of waste heat from gas engines through the Merriam process, as developed by the Bruce-Macbeth Co. By forcing the water in a closed circuit through the jackets at a velocity five to ten times normal, the temperature can be raised to 300 deg. without endangering the cylinder. Thus steam under pressures as high as 50 lb. can be generated and the heat usually wasted in the jackets is utilized.

During the past year important experiments have been conducted by the Engineering Experiment Station of the Pennsylvania State College to determine the applicability of kerosene, alcohol, motor spirits and mixtures of gasoline and kerosene as substitutes for gasoline in engines, also the effect of water injection with these different fuels. Some interesting results were obtained and it is evident that these investigations are timely, for in the United States alone in 1914 it is estimated that 25 million gallons of gasoline was consumed.

The immense combination steam-gas engines for the Ford Co. are nearing completion. The large Humphrey pump has been given mention. During the year several firms have started to build Diesel and semi-Diesel oil engines and several oil engines of the two-cycle, heavy-duty type have been put on the market. An interesting innovation in the delivery of oil fuel has been introduced by the government at Fort Baker, Calif. Oil is piped through the streets in the same way as water and gas. It is delivered to residences and other buildings at 30 lb. pressure for use in furnaces, for heating and cooking and in oil engines for power. This installation and the one at the Presidio, San Francisco, are believed to be the first of their kind ever attempted on a large scale.

Water Power

During the past few years the Pacific Coast has come forward with a greater increase in water-power development than any other section of the United States. Immense projects have been completed recently and others are in prospect, but even with the rapid progress that has been made only 7 per cent. of the total potential water power in the three Coast states has been developed. Tennessee, Georgia, the Carolinas and Minnesota have also been active. During the year the low-head 10,500-hp. development at Coon Rapids, which is to serve Minneapolis, was put into commission. The recent agreement between the Secretary of Agriculture and the state water commission of California on the use of water-powers within the national forests will facilitate developments in this territory. The Adamson bill, which passed the House of Representatives on Aug. 4, was a noteworthy attempt to ward off a monopoly in water power still open to title. The regulation of service and rates was to be left to the states. With this provision the governors in their annual conference at Madison, Wis., were in accord, as they unanimously favored state control of natural resources, notwithstanding their declarations to the contrary in former years.

Engineering Societies

Leading engineering societies of the country are becoming more active than ever before in the interests of their respective fields. As their rosters contain the engineering brains of the country, it is natural to expect that they should formulate standards of design, inspection or testing, and through the exchange of ideas on leading topics guide practice more swiftly into channels of economy and safety. It is gratifying to note that their recent work has been particularly well done and should result in lasting benefit. At a meeting early in the year between representatives of the various engineering societies concerned and the manufacturers' committee, practically all differences between the two schedules of flanged fittings were eliminated. There is still a conflict of opinion concerning the name by which the final schedule shall be known, but a committee has been appointed to smooth out this difference.

The work of the committee appointed by the American Society of Mechanical Engineers to draw up standard specifications for the construction of steam boilers and other pressure vessels and for their care in service has been recorded in these columns. The tentative report of the committee has been sent to leading authorities of the civilized world and at a special meeting all parties interested, including steel and boiler manufacturers, were invited to discuss the report. At the annual meeting held in December it was expected that the committee would be able to present its recommendations revised in the light of the discussions and in final form at the spring meeting in 1915. The report is voluminous and is of the greatest importance to engineers and the public at large, as it involves every item of consequence in relation to the safety of steam boilers, from the specifications of steel to the qualifications of men in the boiler room. The boiler makers have already organized to urge the adoption of these rules by all of the states so that their product may be standardized the country over. Due to the magnitude of the movement more progress with the various state legislatures may be expected in the year to come than in all the years that have gone before.

The report of the power test committee of the same association has now been revised and is being put into final form. Its purpose was to standardize the methods of testing the various types of prime mover and auxiliary apparatus. It will constitute one of the most comprehensive publications ever issued by the society.

Plans for the International Engineering Congress to be held in September of next year at the Exposition are well under way. It is to be conducted under the auspices of five leading national associations and will be presided over by Col. George W. Goethals, who has accepted the office of honorary president.

Boiler Explosions

During the first half of the year 1914 there occurred 340 boiler failures of a more or less serious nature. The number reported killed was 120 and injured 240. The estimated monetary loss was reported in 80 cases only; the total for these was, however, $246,000, making an average of about $3000. The greatest loss, $100,000, was from fire following the boiler explosion. The losses resulting from minor failures are not often given, therefore the average loss is higher than would be the case if all were included. Of the strictly power-plant failures 60 were tube failures, 30 were due to cast-iron headers in water-tube boilers, and 17 blowoff pipes gave way.

Cast-iron heating boilers, as used or neglected, are shown to be a menace of no small proportion. More than 70 are reported to have failed. To repeat a statement of a year ago, "more attention should be given to this type of boiler."

License and Inspection Laws

Relative to the passage of state license and inspection laws, last year's work was barren of results. The National Association of Stationary Engineers continued the work it has been conducting for years, and as usual appropriated funds for this purpose. Fewer legislatures in session and a difficulty in convincing those that were, are the reasons given. To obtain uniform laws the association has offered to coöperate with the American Society of Mechanical Engineers.

In Canada a committee of chief boiler inspectors from the different provinces is drawing up a uniform set of regulations which will be adopted by the entire dominion. During the year rules for the inspection and operation of stationary boilers in the Canal Zone were issued by an executive order of Governor Goethals.

For the safe use and handling of refrigerants the Fire Prevention Bureau of New York City has formulated a set of regulations which went into effect five days ago. Boston also has some ideas on the subject. If regulation is needed in these cities, it is needed in every city or state in the country. The regulations, however, must be sound and safe, and a uniform code is by all means desirable.

Isolated Plant vs. Central Station

The controversy between isolated-plant and central-station interests continues, and no abatement may be expected until the legitimate field for each is more definitely established. Indications, however, point toward progress for the former. Such notable examples as the Ford Buildings in Detroit, the Federal Building in Chicago and many others in which isolated plants have effected large savings are proving beyond the question of a doubt the extravagance of buying current, at a rate profitable to the producer, when heating is to be done. The prolonged delay and final reopening of the Edison rate case in New York City also points in the same direction. Discrimination against the small user of current who cannot compete is having its effect either in a reduction of rates by public service commissions or in crystallizing sentiment toward municipal ownership. At the meeting of American mayors in Philadelphia last November the sentiment for municipal ownership of all public utilities was remarkably strong. The body was representative of cities large and small from one coast to the other. If the convictions of the mayors are backed by a majority of their respective constituents, city-operated plants should soon be the rule and not the exception. Pasadena, Cleveland, Detroit, in their street and public lighting, and many other cities are showing that a municipal plant is a profitable investment when run on a business basis.

Honor Roll

Last year medals innumerable were awarded for bravery, generalship and what not pertaining to war, but for scientific achievement the only two recipients of which we have knowledge were Prof. John E. Sweet, who was presented the John Fritz medal, and Charles F. Brush, of arc-light fame, with the Edison medal. Earlier in the year the former was given the degree of doctor of engineering by Syracuse University. The honorary degree of master of science was conferred upon Gano Dunn, president of the J. G. White Engineering Corporation, in recognition of accomplishments and distinction in science and electrical engineering. The Nobel prizes were suspended. Of the various national engineering societies in this country closely related to the power-plant field the following men were elected to the presidency: John A. Brashear, American Society of Mechanical Engineers; C. O. Mailloux (second year of term), American Institute of Electrical Engineers; H. H. Scott, National Electric Light Association; F. L. Ray, National Association of Stationary Engineers; Samuel R. Lewis, American Society of Heating and Ventilating Engineers; Louis Doelling, American Society of Refrigerating Engineers.

Necrology

Men of prominence in the field who passed away during the past year are mentioned in the following list: Prof. W. D. Marks, well known in engineering circles; E. E. Nolan and William Cooper, of the Westinghouse Electric & Manufacturing Co.; George J. Weber, former president of the Weber Gas & Gasoline Engine Co.; John C. Kelley, founder and only president of the National Meter Co.; Franklin Phillips, president of the Hewes & Phillips Iron Works; Edwin M. Hall, treasurer of the Jefferson Union Co.; Eugene McSweeney, president of the United States Graphite Co.; Prof. E. J. Houston, co-inventor with Prof. Elihu Thomson of the first successful arc-lighting system; Columbus Dill, known by engineers throughout the country; George Westinghouse, the well known inventor and engineer at the head of the Westinghouse interests; John F. Shearman, perhaps better known by his nom-de-plume, Peter Van Brock; Edwin M. Coryell, for many years consulting engineer for the Cameron Steam Pump Works; James W. Thomson, chief engineer U. S. N., retired; Walter Laidlaw, secretary of the International Steam Pump Co.; H. R. Gilbert, manager of the Continental Works of the National Tube Works Co.; W. F. Crane, member of the family known all over the country as engineers; John Erwood, consulting mechanical engineer and inventor of the various valves and water-tube boiler bearing his name; George Willard, formerly connected with the Murray Iron Works Co.; M. Carels, one of the founders of the firm of Carels Frères; Sir Joseph W. Swan, one of the early inventors of the incandescent electric light; Frank L. Busey, engineer of Buffalo Forge Co.; George N. Nistle, vice-president of the Illinois Engineering Co.; Quimby N. Evans, senior partner of the firm of Evans, Almirall & Co.; Edward B. Denny, past-president of the National Association of Master Steam and Hot Water Fitters; Edwin F. Williams, an authority on steam engines and a prominent designer; John B. Allen, a prominent engineer and salesman, formerly vice-president and general manager of the Allis-Chalmers Co. and later Western sales manager for the Westinghouse Machine Co.; Albert B. Franklin, a well known heating and ventilating engineer; J. H. Millett, president of the Crosby Steam Gage & Valve Co.; T. G. Meier, vice-president and treasurer of the Heine Safety Boiler Co., and Col. E. D. Meier, president of the same company and one of the most eminent mechanical engineers in the country, and Charles A. Moore, president of Manning, Maxwell & Moore and identified with the Shaw Electric Crane Co., the Consolidated Safety Valve Co., the Ashcroft Manufacturing Co., the Hancock Inspirator Co., and the United Injector Co.

Engineers' Wages

That the wages of engineers are not the same in Wichita, Kan., as they are in Foxboro, Mass., worries one of our contributors in this issue (page 18). He went to the trouble of sending about seventy-five letters to engineers in widely separated parts of the country and found that there is no consistency in the salaries paid engineers in similar sized plants. After all it is not surprising; doctors right in the same city get widely different prices for the same operation (sometimes their fee depends on what the patient is able to stand financially). So it is in all professions and trades (except where unions have artificially fixed the scale of wages); workers are rewarded according to their ability, and their availability. Relative competence makes for differences in wages, and supply and demand have as much influence on the labor market as any other. Mr. Pagett has made an interesting little research into a subject we are all much concerned about, but we do not look for any changes in conditions in consequence of it.

Central stations in Germany are showing less loss of business, because of the war, than would be naturally expected, according to a report. Thi would seem to prove that they are a more hardy kind of vegetation than isolated plants. *Auch*, weeds are harder to kill than things you want to raise.

Someone has said that "while figures do not lie, liars sometimes figure." This is not to cast any reflections on those who have taken part in the discussion of the engine for the Karpen plant (page 27), but to emphasize the possibility of arriving at results which prove one thing, or the contrary, according to the assumptions that are made before, during or at the end of the calculations. One guess is as good as another and neither can be bolstered up with mathematics. It is still a guess, however much it may be concealed in figures to give it an air of truth.

Correspondence

Why Did the Gage Hand Vibrate?

Our six 66-in.x16-ft. return-tubular boilers are connected to a common header from which steam is taken for two 30, 52 and 61½x36-in. cross-compound pumping engines. Between the hours of six and nine in the morning and evening, the hand of the recording steam gage vibrated considerably. This action continued for five days, or until the oiler opened wide the valve to the gage, allowing the hand to vibrate rapidly. When the valve was closed to the normal opening, the vibration ceased and has not occurred since.

We are wondering what the cause of the trouble was, and would be pleased to read what some readers think was the cause.

A. E. Aldrich.

Newman, Calif.

Engine for Karpen Plant

The article in Power of Oct. 27 dealing with the Karpen factory plant is well worth the attention of every operating engineer, as it illustrates some of the problems entering into the choice of an engine. However, in the writer's opinion, the results obtained were not quite fair to the compound engine.

Before entering upon that phase of the subject attention is called to the efficiency allowed the generator of the compound unit. It is evident that this machine was of inferior make to show only 90 per cent. efficiency. The writer is fairly familiar with the standard makes and in no case has an efficiency as low as this been encountered when the machine was larger than 75 kw. The correct thing would have been to substitute a better generator.

Then, as regards the extra charge for oil for the compound engine, it would seem that $100 is too much to add. In the yearly report at the end of the article, it was shown that the cost of all the oils used in the entire plant was only $112.64 for six months; surely the oil charge for the simple engine only would not exceed $100 per year. If this be true, then the additional oil used on a compound engine would not exceed $25; for the cylinder oil would be almost the same as on a simple engine, while the engine oil should be approximately the same in either case.

Approaching the question of fuel cost of the two installations, it must, first of all, be understood that in arriving at the solution of the question as to the best unit to install, the steam-heating question must also be considered. It is evident that with the steam heating eliminated, the compound engine would be the one to purchase. But the steam heating complicates the problem and it is necessary to consider its effect on the steam cost.

First, take the simple engine. It is to develop 250 kw. 10 hr. per day for 300 days, with a water rate of 24 lb. per i.hp.-hr., engine efficiency 93 per cent., dynamo efficiency 92 per cent. Then the amount of steam passing through the simple engine hourly during the eight heating months would be

$$\frac{250 \times 24}{0.93 \times 0.92 \times 0.746} = 9404 \textit{ lb.} \qquad \text{(A)}$$

The B.t.u. passing into the heating coils at a pressure of 16 lb. abs. would be

$$9404 \times 1034.1 = 9{,}724{,}676 \qquad \text{(B)}$$

This amount of heat is absorbed by the heating system and should be charged against it. In live steam at a pressure of 140 lb. abs. it is equivalent to

$$\frac{9{,}724{,}676}{1192.2} = 8157 \textit{ lb.} \qquad \text{(C)}$$

Whether expressed in B.t.u. or in equivalent pounds of live steam, this is the heat the simple engine has supplied the heating system and its cost must be charged against it.

With an evaporation of 7 lb. of water per pound of coal, the latter costing $3 per ton, the charge per hour against the heating system would be

$$\frac{8157 \times \$3}{7 \times 2000} = \$1.748 \qquad \text{(D)}$$

Likewise, since the simple engine handled 9404 lb. of steam, the charge against both engine and heating system per hour would be

$$\frac{9404 \times \$3}{7 \times 2000} = \$2.015 \qquad \text{(E)}$$

For ten hours per day for eight months the cost would be

$$\$2.015 \times 10 \times 200 = \$4030$$

It is self-evident that the difference between (D) and (E) is the actual cost of the heat used in the simple engine. Thus, per hour, this amounts to

$$\$2.015 - \$1.748 = \$0.267 \qquad \text{(F)}$$

Taking up the operation of the compound during the eight heating months it is found that the engine has a water rate of 20.5 lb. per i.hp.-hr. Developing 250 kw., with an engine efficiency of 88 per cent. and a dynamo efficiency of 90 per cent., the steam passing through the engine per hour would be

$$\frac{250 \times 20.5}{0.90 \times 0.88 \times 0.746} = 8674 \textit{ lb.} \qquad \text{(G)}$$

The heat units given up to the steam-heating coils would then be

$$8674 \times 1034.1 = 8{,}969{,}783 \textit{ B.t.u.}$$

Since all the exhaust from the simple engine was to be used, then if the compound engine was to be installed there would not be sufficient exhaust steam. This would necessitate using live steam to make up the difference. Since the simple engine would supply 9,724,676 B.t.u. and the compound only 8,969,783 B.t.u., the difference would be

$$9{,}724{,}676 - 8{,}969{,}783 = 754{,}893 \textit{ B.t.u.}$$

Expressed in equivalent pounds of live steam at 140 lb. abs., this would amount to

$$\frac{754,893}{1192.2} = 633\ lb. \quad \text{(H)}$$

The operation of the compound would therefore cause the consumption of not only the steam passing through it, but also of a quantity of "makeup" steam. The total amount per hour would be

$$8674 + 633 = 9307\ lb. \quad \text{(I)}$$

The fuel cost per hour would be

$$\frac{9307 \times \$3}{7 \times 2000} = \$1.99 \quad \text{(J)}$$

Then the cost of steam per hour which should be charged against the compound engine would be

$$\$1.99 - \$1.748 = \$0.242 \quad \text{(K)}$$

Since the engines were to operate for two-thirds of the working year, ten hours per day, under these conditions, the charge against the simple engine would be

$$\$0.267 \times 200 \times 10 = \$534$$

and against the compound engine

$$\$0.242 \times 200 \times 10 = \$484$$

Taking up the peak load of 75 kw., which occurs for three hours per day for 100 days each year, it is necessary to go through the same process. These calculations, simplified, are as follows: Steam passing through simple engine

$$\frac{75 \times 3 \times 100 \times 24}{0.93 \times 0.92 \times 0.746} = 846,395\ lb.$$

Cost of this steam

$$\frac{846,395 \times \$3}{7 \times 2000} = \$181.37$$

Equivalent live steam supplied coils

$$\frac{846,395 \times 1034.1}{1192.2} = 734,153\ lb.$$

Cost of steam for coils

$$\frac{734,153 \times \$3}{7 \times 2000} = \$157.32$$

Steam passing through the compound engine

$$\frac{75 \times 3 \times 100 \times 20.5}{0.90 \times 0.88 \times 0.746} = 780,721\ lb.$$

Equivalent steam furnished heating system

$$\frac{780,721 \times 1034.1}{1192.2} = 677,188\ lb.$$

Amount of live steam that must be added on account of compound engine not supplying enough

$$734,153 - 677,188 = 56,965\ lb.$$

Cost operating compound and heating system

$$\frac{(780,721 + 56,965) \times \$3}{7 \times 2000} = \$179.50$$

Fuel cost operating compound engine

$$\$179.50 - 157.32 = \$22.18$$

Fuel cost operating simple engine

$$\$181.37 - 157.32 = \$24.05$$

Considering the four months where 30 per cent. of the exhaust steam is wasted, the simple engine is using

$$\frac{250 \times 10 \times 100 \times 24}{0.93 \times 0.92 \times 0.746} = 9,404,389\ lb.$$

The cost of the steam passing through the simple engine is

$$\frac{9,404,389 \times \$3}{7 \times 2000} = \$2015.23$$

The equivalent live steam supplied the heating system and used is

$$\frac{(9,404,389 \times 1034.1)}{1192.2} \times \frac{70}{100} = 5,710,078\ lb.$$

Cost of exhaust heating

$$\frac{5,710,078 \times \$3}{7 \times 2000} = \$1223.59$$

Charge against simple engine

$$\$2015.23 - \$1223.59 = \$791.64$$

The compound engine during this time would use

$$\frac{250 \times 10 \times 100 \times 20.5}{0.88 \times 0.90 \times 0.746} = 8,674,678\ lb.$$

Cost of steam

$$\frac{8,674,678 \times \$3}{7 \times 2000} = \$1858.86$$

Charge against compound engine

$$\$1858.86 - \$1223.59 = \$635.27$$

Then the total fuel charge against the simple engine would be

$$\$534 + \$24.05 + \$791.64 = \$1349.69$$

The total charge against the compound engine would be

$$\$484 + \$22.18 + \$635.27 = \$1141.45$$

The summary of total charges would then become

	Simple Engine	Compound Engine
Fixed charges	$1435.92	$1568.00
Fuel	1349.69	1141.45
Extra oil	......	25.00
Total	$2785.61	$2734.45

So that, even in the face of an excessive depreciation charge, the compound proves more efficient.

The engineer calculated that 25 per cent. of the two total charges would be eliminated by using shavings. This is wrong since both heating and power are under consideration. If power were purchased then the shavings could be used in supplying the live steam to the heating system so that the entire fuel charge against either engine represents coal purchased. But assume that the engineer's contentions are correct, then the fuel for the simple engine would be represented by coal, $1012.27, and shavings, $337.42. Then since the total fuel charge of the compound is $1141.45, this would be divided as follows: Shavings, $337.42; coal, $804.03. This is true as the amount of shavings available is the same regardless of the kind of power. Then the summary becomes

	Simple Engine	Compound Engine
Fixed charges	$1435.92	$1568.00
Coal	1012.27	804.03
Extra oil	......	25.00
Total	$2448.19	$2397.03

L. H. Morrison.

Dallas, Texas.

The above discussion is interesting as it attacks the problem from a different angle than the method employed by Mr. Ory. The latter figured each machine independently and divided the cost for steam between the engine and the heating system on the basis of the heat units utilized. Mr. Morrison does the same thing for the simple engine. With the compound engine, he supplies the same amount of heat to the heating system by finding the deficiency in the exhaust, reducing it to its equivalent in live steam and charging it, along with the steam actually utilized, against the compound engine.

In the cost of fuel, per year, he finds a difference of $208.24 in favor of the compound engine. By Mr. Ory's method the saving in fuel effected by the use of a compound engine amounted to $67.25. Using the same fixed charges and reducing the extra oil required by the compound from $100 to $25, Mr. Morrison finds a balance of $51.16 favoring the compound engine. In his figuring Mr. Ory shows a gain of $164.83 for the simple engine.

Although it was not so stated in the article, the oil item of $100 was intended to include additional supplies required. The exact amount to charge is, of course, a matter of judgment, but in the writer's opinion the item should be much nearer $100 than $25. The efficiencies for the compound unit were placed low, as a price $766 lower than for the simple engine indicated light and cheap construction. Naturally, this would result in lower economy and greater depreciation.

An item which would affect the balance considerably, not touched upon in the above discussion, is the cost of the compound engine. A compound unit of equal quality should cost about one-fourth more than the simple unit, or, in round numbers, $15,000. Then reducing the depreciation to the 5 per cent. assumed for the simple engine, the fixed charges are higher by $232 and $364 more than for the simple engine. Raising the efficiencies of the compound engine and generator to those of the simple unit would slightly reduce the fuel cost for the compound, but there would still be a considerable balance in favor of the simple engine.

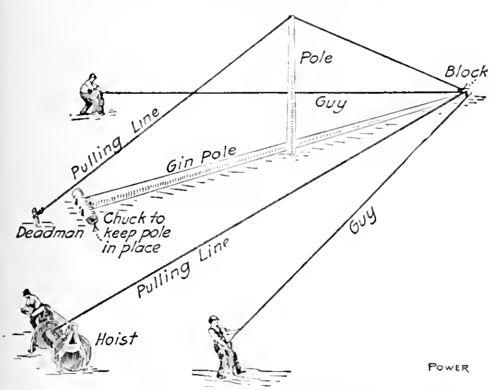
The above figures are, of course, arbitrary, as they are all based on assumptions, but, generally speaking, when practically all of the exhaust steam is used in the heating season and 70 per cent. of it in the summer months, there is little need for a compound engine. The small saving in coal that might be effected will not warrant the additional expenditure usually required for a good compound unit.

Thomas Wilson.

Chicago, Ill.

Raising a Gin Pole

There are occasional articles in Power regarding the erection of smoke-stacks, but I have never noticed any information on how to raise a gin pole with which to begin the stack-raising job. Here in Alaska we use from forty-



Approximate Positions of Men Raising Gin Pole

to sixty-foot gin poles and raise them off the ground without a mast. We require only three men, two at the guys and one at the hoist.

When the pole is laid in place, the guys are put on, a block of wood or a cable at the butt keeping the pole from moving ahead. A single pulley block is fastened at the top. The pulling line runs from the hoist through the block back to a fixed point or dead-man in line with the gin pole. A pole about fifteen feet long, having a small notch cut in one end, is placed vertically under the pulling line about midway of the gin pole. When power is applied and the pulling line tightens up, the pole is raised off the ground. After it is up some distance, the pole under the cable is released and falls, but the hoist keeps on pulling until the pole is up. (The illustration does not show the fixed points in their true relative positions on account of lack of space.)

This is a simple and quick way to raise a pole.

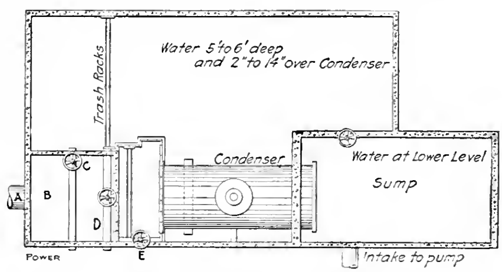
Edward M. Keys, Jr.

Chatanika, Alaska.

Novel Condenser Setting

While visiting the La Habra Valley Water Co.'s plant, near Whittier, Calif., I saw what I thought was a good condenser setting.

A surface condenser was set in an enlarged section of



Condenser in Intake Canal

the intake canal into which the water flows by gravity from wells in the hills. The general layout is shown in the illustration. The water enters through conduit *A* into receiver *B*. From there it is bypassed through gate *C* or through the condenser tubes by opening gate *D*, and by adjusting the two gates the flow is regulated.

Gate *E* may be used to drain off the water for cleaning out or repairing the condenser or basin. All the other details are as in the average surface condenser plant. The prime object is, of course, saving power by avoiding handling the cooling water with a pump.

C. R. Clark.

Anaheim, Calif.

Finding the Value of Coal

The writer encountered a case recently in which there was a possibility of considerable saving if a certain coal could be economically used. His plant is served by two rival roads which will be designated A and B. A good free-burning coal had been obtained on road A, but its unloading switch was so far from the boiler room that it cost about ten cents a ton to haul the coal. As road B could bring coal directly to the boiler-room door, it was desirable to thus obtain the coal and save the additional expense.

After trying several more or less unsatisfactory coals a coal was found which could be obtained by road B and which, with the same cost per ton on the switch, gave better results by a laboratory test than the coal which had been formerly shipped on road A. Upon testing in the boiler room, however, it clinkered badly and gave a low evaporation. The practical test alone would probably have proved the coal unsatisfactory. As the analysis was good it was decided to experiment further with the coal. In the course of a few days, it was found that by altering the depth of fire carried and the method of firing, the coal could be burned without serious clinkering. The evaporation went up, and this coal has since proved more satisfactory than that formerly used. At the same time, 10c. a ton has been saved on handling.

In this case the plant superintendent acted as his own chemist and he was fortunate in having an engineer who was broad-minded, eager to produce results and to save money for his company.

The writer does not argue that any coal which appears well from a laboratory test can be used economically in regular operation, but a good showing by a coal in the laboratory, if properly considered, will result in an exhaustive test in the boiler room and may be the means of saving much money.

WILLIAM A. DUNKLEY.

Atlantic City, N. J.

Water-Hammer in Blowoff Pipes

In boiler plants where the main blowoff header leads into a catch basin emptying into the city sewer through a small drain, care should be taken to avoid water-hammer. If the basin fills up above the end of the blowoff, the water will flow back into the pipe as it cools slightly; then if another blowoff valve is opened before the water recedes, water-hammer is almost sure to occur. I know of such a case where one man lost his life when a fitting ruptured. Beware of short bends and water in blowoff pipes.

JOHN F. HURST.

Louisville, Ky.

Water End of Pump Was Vapor Bound

In starting four feed pumps in a new power house not long ago, it was discovered that the feed-water heaters were set too low to supply the upper suction-valve chambers of the vertical feed pumps when the water was over 200 deg. F. The erecting and consulting engineers admitted that a mistake had been made, but they were powerless to remedy it. After it had become necessary to cut the steam off the heaters to secure quiet working of the pumps, reducing the feed-water temperature to 150 deg. F., the operating engineers connected a pipe between the upper suction-valve chamber of the vertical duplex feed pump with the return tank, so as to relieve the heater of the high back pressure.

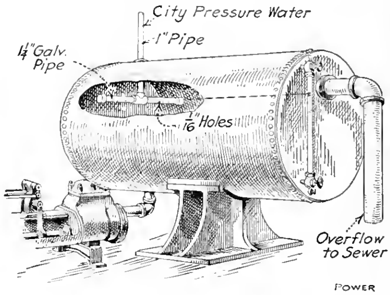
Weaker springs were put on the upper suction valves so that the valves would open and admit water at a lower vacuum than before the change. The vapor which heretofore filled the suction pipe and pump-valve chambers now found an outlet through the vapor pipe. The result was that the pump worked without slamming and the feed-water temperature increased to 210 deg. F.

JACOB R. REZNIEM.

Brooklyn, N. Y.

Oil Skimmer

The illustration shows an oil skimmer which I believe will clear the receiver of most of the cylinder oil. At one end of the receiver is a spray pipe with holes in only one side. City water is turned on when the receiver is



PERFORATED PIPE IN RECEIVER

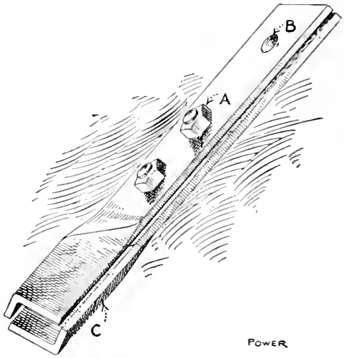
overflowing and the force of the spray skims the oil from the water and drives it toward the overflow and to the sewer. If this is done once a day there will be little or no trouble from cylinder oil.

A. C. WALDRON.

Revere, Mass.

Adjustable Socket Wrench

The illustration shows how a handy adjustable socket wrench may be easily made. One end of two flat bars is formed as shown at *C*. Bolts *A* should be threaded for



HOME-MADE WRENCH

quite a length to afford adjustment. A hole *B* will be found convenient at the top for a bar to turn the wrench. An extension bar may be used to lengthen the wrench when used in a cramped place.

JAMES E. NOBLE.

Toronto, Ont.

Inquiries of General Interest

Common Exhaust Line for Several Engines—Is it good practice to have several noncondensing engines exhausting into one exhaust line?

E. C. P.

It is general practice to have a common exhaust line for several engines, and it works satisfactorily providing the main exhaust line is large enough for handling the exhaust from all the engines without materially increasing back pressure on any of them.

Temperature of Oil Discharged from Step Bearings of Steam Turbines—What temperature is proper for oil discharged from the step bearing of a steam turbine?

B. H. C.

The maximum oil temperature permissible will be determined by the viscosity of the oil for the temperature at which it is discharged. Using a good quality of oil for the step bearings of large vertical Curtis turbines the temperature of the discharged oil is about 150 deg. F., thereby attaining a rise of about 50 deg. F.

Cost of Operating Electric Motor—What would be the cost of operating a 100-hp. motor using current costing 2c. per kw.-hr.?

C. W. R.

One horsepower equals 746 watts, and 100 hp. would equal 100 × 746 watts, or

$$\frac{100 \times 746}{1000} \text{ kw.}$$

With a motor of 91 per cent. efficiency, the input required for an output of 100 hp. would be

$$\frac{100 \times 746}{1000 \times 0.91} \text{ kw.}$$

and with current costing 2c. per kw.-hr. the cost would be

$$\frac{100 \times 746}{1000 \times 0.91} \times 0.02 = \$1.64 \text{ per hr.}$$

Variation of Water Column for Difference of Temperature—When our boiler is operated at 100 lb. gage pressure, and the temperature of the water in the column and connections is 95 deg. F., the water level shown by the glass gage is 30 in. above the point where the water column connects with the boiler. How much higher would the water level show in the glass gage if the temperature were the same as the temperature of the water in the boiler?

M. C. R.

For 100 lb. gage pressure the temperature of the boiler water would be about 338 deg. F. A cubic foot of water at 95 deg. F. weighs 62.06 lb. and at 338 deg. F. weighs 56.01 lb. For producing the same hydrostatic pressure at the foot of the connection the height of water column would be inversely as the density of the water. Therefore with a density corresponding to the temperature of the boiler water the water level would stand

$$(30 \text{ in.} \times 62.06) \div 56.01 = 33.24 \text{ in.}$$

above the foot of the connection—i.e., it would show about 3¼ in. higher level than with the water in the connections at 95 deg. F.

Obtaining Absolute Pressures from Gage Readings—Why can not the dial of an ordinary Bourdon spring pressure gage be laid off to indicate absolute pressures by direct readings?

C. J. R.

The tube of a Bourdon spring gage is moved by the difference of pressure inside and outside of the tube, and for indicating absolute pressure either the interior or the exterior pressure would have to be constant. As ordinarily constructed the exterior of the tube is exposed to atmospheric pressure, and as this is variable the dial is laid off only for pressures above or below the atmosphere. Hence "0" gage pressure is atmospheric pressure, and as the gage indicates the difference between atmospheric pressure and the internal pressure, then when the internal pressure is greater than atmospheric pressure, as in the ordinary pressure gage, the absolute pressure will be gage pressure plus atmospheric pressure. When the internal pressure is less than atmospheric pressure, as in the case of a vacuum gage, the absolute pressure will be the atmospheric pressure minus the difference of pressure indicated.

Heating Value of Steam at 4 lb. and at 80 lb. Pressure—What is the relative heating value of steam at 4 lb. and at 80 lb. gage pressure when used in a pipe coil or radiator and discharged to a trap?

H. W. J.

Considered with reference to the weight of steam received by a radiator and discharged as condensate at the same pressure, the heating value in each case would be its latent heat of evaporation. The latent heat of a pound of steam at 4 lb. gage pressure is about 962 B.t.u., and for 80 lb. gage pressure it is about 891 B.t.u. Therefore, the heating value of steam at 4 lb. pressure would be $\frac{962}{891}$ times, or have about 7 per cent. greater heating value than the same weight of steam received and discharged as condensate at 80 lb. pressure.

Considered with reference to heating effect from a given amount of radiator surface, the steam of higher pressure would also be at a higher temperature and the radiation of heat would be more rapid, depending on the difference between the temperature of the steam and that of the surrounding atmosphere. With the temperature of the surrounding atmosphere at 70 deg. F. in each case, then as the temperature of steam at 4 lb. gage pressure is about 225 and at 80 lb. gage pressure is about 324 deg. F., for the same radiating surface the relative rate of radiation would be (225 — 70) to (324 — 70), or as 155 to 254—i.e., only about $\frac{155}{254}$ or 61 per cent. as much heat would be radiated from a coil or radiator supplied with steam at 4 lb. as from one supplied with steam at 80 lb. gage pressure.

Factor of Evaporation with Superheater—What would be the factor of evaporation for the performance of a boiler with a superheater where the following averages were observed?

Absolute steam pressure in steam drum......	150 lb. per sq.in.
Absolute steam pressure at entrance of superheater	149 lb. per sq.in.
Absolute steam pressure at outlet of superheater	147 lb. per sq.in.
Temperature of steam at outlet of superheater.	478.5 deg. F.
Temperature of feed water	100 deg. F.

W. F.

Considering the superheater as a part of the boiler, the factor of evaporation of the boiler should be based upon the pressure and temperature of the steam at the outlet of the superheater, viz.: 147 lb. absolute and a temperature of 478.5 deg. F. The temperature of dry saturated steam at 147 lb. absolute is 356.9 deg. F., therefore a temperature of 478.5 deg. F. would represent

$$478.5 - 356.9 = 121.6 \text{ deg. of superheat.}$$

Referring to the Marks and Davis steam tables, the total heat of a pound of steam at 147 lb. absolute when superheated 120 deg. F. is 1259.4 B.t.u. above 32 deg. F., and when superheated 130 deg. F. is 1264.5 B.t.u. By interpolation between these values, the total heat per pound of steam at 147 lb absolute, superheated 121.6 deg. F., would be

$$1259.4 + \left[\left(\frac{1264.5 - 1259.4}{130 - 120}\right) \times (121.6 - 120)\right] = 1260.21 \text{ B.t.u.}$$

so that with feed water at 100 deg. F. each pound of feed water evaporated into steam at 147 lb. absolute and 478.5 deg. F. would receive

$$1260.21 - (100 - 32) = 1192.21 \text{ B.t.u.}$$

The latent heat of evaporation of water from and at 212 deg. F. being 970.4 B.t.u. per lb., the factor of evaporation under the condition stated would be

$$\frac{1192.21}{970.4} = 1.2286$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design--XII

WATER SUPPLY AND FIRE PROTECTION, CONTINUED

The quantity of water required and the horsepower necessary for pumping it from the river to the reservoir have already been approximated, but in designing the pumping outfit it will be necessary to go over the matter a little more carefully.

The maximum supply was based on that required for condensing and was taken as 7000 lb. approximately per min. This made an allowance for the exhaust from auxiliaries and assumed that the total amount of steam supplied to the engine would be discharged into the condenser.

In the final arrangement of the plant it was decided to utilize the exhaust from the auxiliaries in a feed-water heater, and in making the more accurate computation we will make use of Table 1 in last lesson, which takes cylinder condensation into account. Thus

$$\frac{670 \times 15 \times 35}{60 \times 8.3} = 707 \textit{ gal. per min.}$$

will be required. It will be remembered that 670 hp. was required for the entire plant: 15 is the water rate minus 10 per cent. and 35 is the pounds of water required to condense a pound of steam.

In the present case the surface of the river is 50 ft. below the power house, so it will be necessary to locate the pump in a special building at such an elevation that the total suction lift will not exceed 15 ft. With this arrangement a motor-driven centrifugal pump would seem to be well adapted to the conditions presented. Such a machine requires but little attention, it may be shut down from the engine room, and power is easily trans-

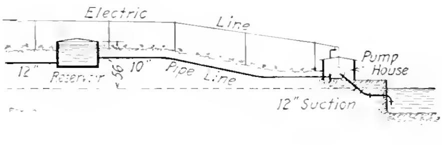


FIG. 1. PUMPING WATER SUPPLY FROM RIVER

mitted from the central plant. There is little choice in a case of this kind between the triplex plunger pump and a centrifugal, but the latter is simpler in construction and may be driven by a direct-connected motor without the use of gears or belts.

In the design of the pumping plant the first step is to find the size of main between the pump and the reservoir, which is usually fixed by the relation between the saving in cost of pipe and the increased cost of pumping against a greater head. A large pipe reduces the friction and therefore saves in pumping expenses, but it costs more to install. Under average conditions a velocity of 2 ft. per sec. for pipes up to 10 in. in diameter, and a velocity of 3 ft. for larger sizes, seem to give about the right balance between the cost of pipe and that of pumping.

A table of velocities and friction heads for water pipe shows that a 10-in. pipe will discharge 750 gal. per min.

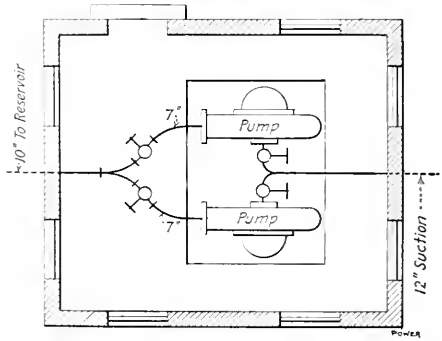


FIG. 2. TWO CENTRIFUGAL PUMPS ON WATER SUPPLY

at a velocity of 3.06 ft. per sec., and with a friction head of 0.18 lb. per in. or

$$0.18 \times 2.3 = 0.41 \textit{ ft.}$$

for each 100 ft. For the entire run of 500 ft. this gives

$$0.41 \times 5 = 2.05 \textit{ ft.}$$

As the run is of comparatively short length, a velocity of 3 ft. per sec. will be assumed and a 10-in. pipe used. Doubling this friction head to include bends and valves, and adding 6 ft. for the elevation of the reservoir, gives a total lift of

$$50 + 4 + 6 = 60 \textit{ ft.}$$

to be pumped against. Assuming a slip of 30 per cent. the pump must have a rated capacity of

$$707 \div 0.7 = 1010 \textit{ gal. per min.}$$

under a head of 60 ft. A table of centrifugal-pump capacities states that a pump with a 21-in. impeller and a 7-in. discharge outlet will deliver 1058 gal. per min. under a 60-ft. head at a speed of 655 r.p.m. This is the size that should be used in the present case. Assuming an efficiency of 60 per cent., the horsepower of motor for driving it will be

$$\frac{707 \times 8.3 \times 60}{33{,}000 \times 0.6} = 18$$

say, 20 hp. to make it a standard size. Two pumping units are provided, Fig. 2, and with the pipe sizes used they may be operated together when a large supply of water is wanted, as in case of fire.

RESERVOIR

It was assumed in a previous article that the reservoir should have a storage capacity equal to that required for a day's run, which we will take as a maximum of 8 hr. and which calls for

$$707 \times 60 \times 8 = 339{,}360 \textit{ gal.}$$

A reservoir 50 ft. in diameter by 30 ft. in height will give an excess capacity of about 100,000 gal. By duplicating the pumping machinery it would probably not be necessary to provide so large a storage reservoir, because in case of a breakdown to both of the pumps the engine could be run noncondensing, and a storage capacity of half the above would be ample for boiler feeding and fire purposes during a temporary shutdown of the pumping plant.

It will be sufficient to provide a concrete reservoir 50 ft. in diameter by 15 ft. in depth, extending 6 ft. above grade. This will make it possible to drain it into the main sewer, and also, under normal conditions, there will be sufficient head to cause the water to flow to the pumps and to the receiving tank and boilers by gravity. Diagrams showing the general arrangement of the pumping machinery, pipe line and reservoir are given in Figs. 1 and 2.

Fire Protection

A system of fire protection consists of two parts—one for outside service, made up of hydrants and their underground connections, and a sprinkler system for inside protection. The rules for laying out a system of this kind vary somewhat in different localities, and the proposed system should be submitted to the fire underwriters for that district before its installation. The following data are general in character and correspond to average conditions.

Water Supply

There should be two independent supplies, one of which should be automatic and capable of furnishing water under a heavy pressure. Common sources of supply are a pond, river or large reservoir from which the water is drawn by a pump, city mains, and elevated or pressure storage tanks. A combination of any two of these will usually give sufficient protection.

Pumps

Standard fire pumps have capacities of 500, 750, 1000 and 1500 gal. per min. The 1000-gal. size is the one most frequently used, although many 750-gal. pumps are installed. The 500-gal. size is only for use in the smallest plants. It is more common to have two smaller pumps than a single large one of 1500 gal. capacity. The pumps most frequently used for this purpose are the direct-acting steam pump, rotary pump and electrically driven pumps, while turbine or centrifugal pumps are also employed to some extent. All of these pumps are made in standard sizes for this purpose. The pumps should always be duplicated and so connected that they may be run either singly or together.

Outside Protection

Hydrants are commonly placed from 150 to 200 ft. apart and provided with two to four hose outlets each, three being the standard. They should be located about 50 ft. from the buildings they are to protect, depending somewhat upon the height. There are two general methods employed for supplying the hydrants, known as the "loop" system and the "dead-end" system; they are sufficiently described by their names. The former is usually preferable, as smaller mains may be used, the supply coming from both directions. The number of hose outlets supplied from mains of different sizes are given in Table 3:

TABLE 3. NUMBER OF HOSE CONNECTIONS

Size of Main, In.	Length of Main, Ft.	Number of Hose Outlets on "Dead-End" System	Number of Hose Outlets on "Loop" System
6	250	3	6
6	500	2	4
4	250	6	10
8	500	4	8
8	1000	3	..

A two-way hydrant should have a 5-in. gate and three- and four-way hydrants have a 6-in. gate. While the largest mains given in the table are 8 in., large plants will often call for 10- and 12-in. mains.

Sprinkler Systems

The spacing of the sprinkler heads will depend somewhat upon the construction of the building. For standard mill construction, the spacing given in Table 4 may be used, with one line of sprinklers in the center of each bay. Pipe sizes are given in Table 5.

TABLE 4. SPACING OF SPRINKLER HEADS

Width of Bay, Ft.	Distance Between Sprinkler Heads, Ft.
6 to 8	12
9	11
10	10
11	9
12	8

TABLE 5. PIPE SIZES FOR SPRINKLER SYSTEM

Pipe Size, In.	Number of Sprinklers	Pipe Size, In.	Number of Sprinklers
1	2	3	36
1¼	3	3½	55
1½	5	4	80
2	10	5	140
2½	20	6	200

When an elevated tank forms one of the supplies for a sprinkler system it should have a capacity of 10,000 to 20,000 gal., 15,000 being about the average.

Pressure tanks may be made somewhat smaller on account of the higher pressure carried. A tank of 6000-gal. capacity corresponds to one of 10,000 of the elevated or gravity type. In practice it is customary to use two or more smaller pressure tanks rather than a single larger one on account of the expense, 8000 to 9000 gal. being about the limit. In general, tanks of this kind are located above the sprinklers, kept about two-thirds full of water and subjected to a pressure of 75 lb. per sq.in., which insures a pressure of 15 lb. when the tank is empty. Both elevated and pressure tanks may be made to connect with a general system of fire mains, from which the sprinkler system takes its supply, provided there is sufficient head to maintain a minimum pressure of 15 lb. at the highest sprinkler heads.

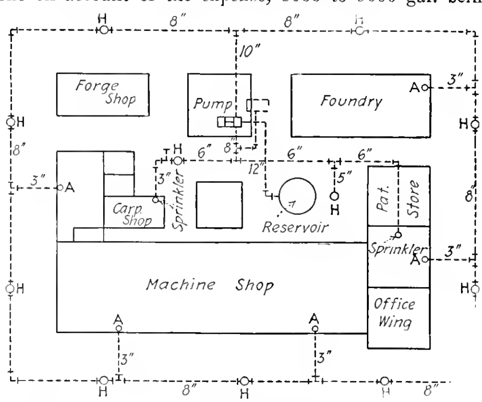


Fig. 3. Layout of Hydrants and Outside Piping

According to Table 4, the following number of sprinklers will be necessary in the rooms to be protected: Office, 40; drafting room, 40; pattern shop, 40; pattern storage, 50; carpenter shop, 24; paint shop, 6; a total of 200.

Assuming that 60 sprinkler heads will require 250 gal. of water per min., the total requirements for one hour for this purpose will be

$$\frac{200 \times 250 \times 60}{60} = 50{,}000 \ gal.$$

which is only about one-third the capacity of the storage reservoir and therefore well within allowable limits.

The general layout of the hydrants and outside piping is shown in Fig. 3. The loop system is employed for the outer system of hydrants, with a dead-end supply for the sprinklers and two yard hydrants as indicated.

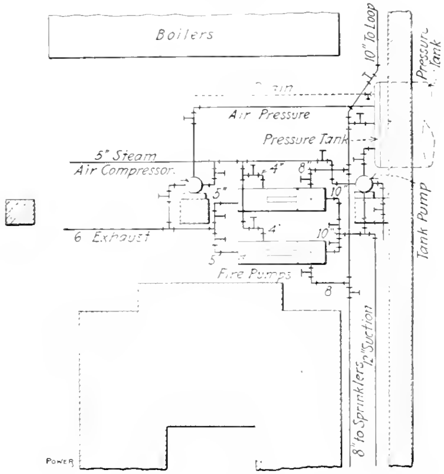


FIG. 4. ARRANGEMENT OF WATER-PRESSURE EQUIPMENT IN POWER HOUSE

Inside standpipes, with hose connections, are provided in the machine shop, office wing, foundry and carpenter-shop storage at the points marked *A* on the plan. While an 8-in. loop has a capacity of but eight hose outlets, it is assumed that not more than this number will ever be in use at one time, although there are 9 three-way hydrants on the line.

The arrangement of the pressure equipment in the power house and the various pipe connections are shown in Fig. 4. A pressure of 100 lb. per sq.in. is constantly maintained on the system for automatic sprinkler supply by means of a pneumatic tank having a capacity of 6000 gal. With the tank two-thirds full and the air space above it subjected to this pressure, there will be at least 15 lb. upon the highest sprinklers when the tank has discharged its entire contents.

The tank is filled by means of a special pump, indicated in the drawing, which should be arranged by means of a float valve to maintain the normal water line automatically and thus offset the effect of any leakage in the system. The pressure should also be maintained automatically by means of a compressor actuated by changes in the system.

Two 1000-gal. direct-acting steam pumps are provided. While one is furnished as a relay, the pipe connections are such that they may be operated together in case of emergency. A pump of the type and capacity used will supply four standard fire streams and will require about 150 boiler-horsepower for operating it.

Scientific Boiler Feeding

By E. W. NICK

It is well known that it is impossible to quickly change the intensity of furnace fires and the rate of boiler feeding with every change of load. When the load changes there should be a corresponding change in the rate of feeding, which should be slow enough to allow a gradual and economical change in the furnace fires.

There are advantages obtained by lowering the water level to secure greater steaming capacity for peak and overloads, and raising it during subnormal and no loads to save heat energy. A continuous feed and a scientifically varied water level are desirable features to obtain by any method of feeding.

When a demand for an additional supply of steam occurs, it is not necessary to immediately increase the supply of feed water. Part of the water already within the boiler and at boiler temperature can be evaporated into steam and this process may continue until the water has dropped to the lowest permissible level. Conversely, when the demand for steam falls off, it is not necessary that the amount of feed water be simultaneously decreased. On the other hand, the amount of water in the boiler can be increased so that the heat which would otherwise be lost is saved and utilized for heating up additional feed water.

Suppose, for example, that the load on a boiler suddenly increased by 100 per cent. If the rate of feeding water were increased at the same time by the same amount, then the furnaces would at once have to generate 100 per cent. more heat in order to keep up the steam pressure. This cannot be done, and therefore the steam pressure drops somewhat and the heat stored in the water is called upon to make steam. Obviously, the last thing to do under such circumstances is to inject a large volume of cold water into the boiler.

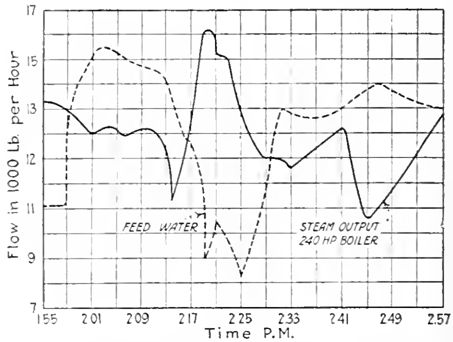


FIG. 1. SIMULTANEOUS READINGS OF FEED-WATER FLUCTUATIONS AND STEAM OUTPUT

If the rate of feeding does not increase when the load increases, then the additional feed water need not be heated and the momentary load on the boiler is increased by only 80 per cent., since the amount of heat required to heat the feed is about 20 per cent. of the total. If the feed water were cut off when the load jumps 100 per cent., then the momentary overload amounts to but 60 per cent.

For high economy, all the boilers in a battery should operate with the load evenly distributed. The efficiency of a boiler falls off gradually as the load is increased and rapidly as the load decreases below normal. It is important that all boilers of a battery work at uniformly high capacities.

Suppose that the five boilers of a battery are working at five capacities and delivering a total of 75,000 lb. of steam per hour with a total battery efficiency of 69 per cent. If the boilers were worked at a uniform high capacity, each of the five boilers would generate exactly one-fifth of the steam and the average battery efficiency would be 72 per cent., or a net gain of 3 per cent.

The unequal distribution of load between the boilers of a battery is caused by differences in condition of fire, of coal, grade of firemen or condition of the stoker, the draft pressure, condition of setting as to leaks, condition of boiler surface as to soot and scale, the position and condition of the dampers, and to the rate of feeding the water.

If a feed-water regulator is so designed that the feed valve cannot assume an intermediate position on light loads, the valve will be closed for long periods and open for short periods. On heavy loads the valve will be wide open for long periods, thus causing a fluctuating steam output and failing to feed in proportion to the rate of evaporation.

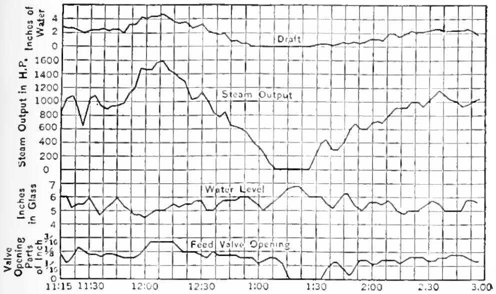


FIG. 2. SHOWING LOAD ARTIFICIALLY VARIED FROM ZERO TO 270 PER CENT. CAPACITY

When feeding by hand regulation, the water tender cannot follow a fluctuating load and at the same time make the proper allowance for the influence of the load and the steam pressure on the height of water observed in the gage-glass. A steam flow meter on each boiler to guide the firemen or stoker attendant has proved successful in regulating individual boiler loads, but hand feed causes wide and misleading fluctuations in steam-flow meter readings. The steam delivery and flow meter reading may be reduced from a heavy overload to practically zero load by the sudden injection of a large volume of cold water. This is illustrated by the curves of Fig. 1, which show simultaneous readings of the feed water and the steam output of a boiler forming one unit of a battery on which there was a constant load, the fireman relying on the steam gage and water column as a guide in regulating the feed water. Under such conditions the advantages resulting from the use of steam-flow meters cannot be realized because the readings cannot be used as a guide to regulation.

The water tender and fireman often work at cross purposes. The fireman assumes that the pressure gage and steam-flow meter readings indicate the boiler and furnace load and the rate at which heat is being absorbed from the furnace by the boiler, whereas the accuracy of the readings may be destroyed and their utility nullified by improper feed.

If every boiler were fed continuously while under load, and if at the same time the water level were varied inversely with the load, this trouble would disappear and all boilers would receive a share of the feed in proportion to the furnace load. If the steam delivery of a boiler, as indicated by the flow meter, is too low, it is corrected by speeding up the stoker, cleaning the fires, opening the dampers and regulating the air supply; then the increased heat generated causes an increased steam delivery, which in turn causes the proper increase in feed supply.

A feed-water regulator should make the rate of feeding dependent upon the furnace load, and so long as each furnace of a battery generates its share of the heat, each boiler of the battery will receive its share of the feed water and generate its share of the steam.

To meet the foregoing requirements an automatic boiler feed regulator should have the following characteristics: On light loads the water level should be high, so that the boiler stores a maximum amount of water and heat. Conversely on heavy loads, the water level should drop, the heat of the furnace being used for evaporating water in the boiler and not heating cold feed.

To secure this fall in water level, the feed valve should close off the feed somewhat, when the load suddenly increases, thus increasing the heat available for evaporating the water already admitted. However, as the water level falls due to evaporation, the regulator must increase the rate of feed until the amount being fed equals the amount being evaporated.

With a sudden decrease in load, the regulator must not decrease the feed until the water level has risen to the maximum and should even open up the feed valve to rapidly inject cold water, so as to absorb the heat which would otherwise be uselessly generated by the furnace. After the water level has reached the maximum permissible height, the feed must be decreased or shut off. Finally, the regulator should be reliable and automatic so that when the load is removed from the boiler the feed water will be shut off.

That these conditions are not impossible of accomplishment with an automatic device is evident from Fig. 2. These readings were taken on a boiler whose load was intentionally varied from zero to 1600 hp., corresponding to almost 300 per cent. rating. The maximum steam output is accompanied by the minimum water level, followed by a rising water level as the load decreased and a maximum water level at the minimum output. The feed-valve opening does not reach the maximum until some ten minutes after the first peak, showing how the water in the boiler is allowed to evaporate down to the minimum level before the feed valve opens to compensate for the increased load.

Similarly, while the load fell to zero at 1:10, the feed valve did not close until some ten minutes later and only after the water level had reached the maximum permissible level and cold water had been pumped into the boiler, so as to store and save heat.

Another proof of the practicability of this method of feed is shown by Fig. 3. This covers readings on the boilers of the Municipal lighting plant, Jacksonville, Fla. The load varied from 1000 to 4000 kw. The water and load lines have the same general shape, indicating that the feed is in proportion to the load. As with the previous chart, however, the feed does not respond to a change in load until the thermal capacity of the boiler has been utilized.

The first example occurred at 4 o'clock, when the load suddenly dropped from over 2000 to just over 1000 kw. This drop in load, instead of causing a decrease in the rate of feed, was accompanied by a rise in the rate of feed from 60,000 to 75,000 lb., the additional water thus pumped into the boiler saving and storing heat. After 4:10 the boilers were obviously filled to the highest permissible level and the rate of feed fell off. The constantly increasing load from this time up to 6 o'clock is accompanied by a corresponding increase in the rate of feed. At the first peak of the load, occurring at 6 o'clock, the amount of water fed to the boiler fell from about 86,000 to 80,000 lb., indicating how this method of feeding helps to carry peaks. At 7:10, when the load went up again to the maximum, the rate of feed fell from 77,000 to 70,000 lb., not increasing again until the peak had persisted for some time, when the water level had fallen and it was necessary to increase the rate of feed to prevent the level from going below the minimum. L. E. Murphy,

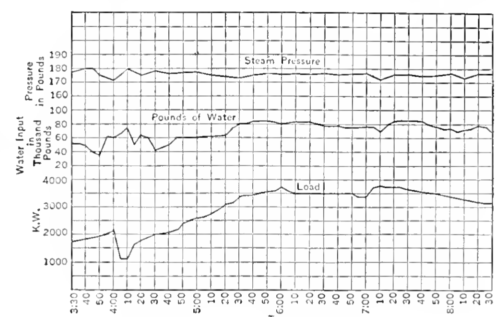


FIG. 3. PERFORMANCES OF FEED-WATER REGULATOR AT MUNICIPAL PLANT, JACKSONVILLE, FLA.

chief engineer of the plant, states that "Our fuel consumption goes up 4 to 5 per cent. for a given kilowatt output when the regulators are not in use."

From the foregoing it is obvious that a continuous-feed regulator makes it possible to use a smaller feed line, smaller valves, and smaller boiler feed pumps for a given boiler horsepower output, or it permits forcing of the boilers without the usual increase in size of lines, fittings and pumps. This is true because the control valve does not close unless the boiler is shut down, and furthermore the valve maintains an intermediate position, so that water is continuously fed to the boiler. As a result, the valve is not called upon to open to its full extent and is operating far below its maximum capacity. On new installations the saving in the cost of fittings covers a large part of the cost of such a regulator. As boilers are driven at higher and higher loads by the use of mechanical draft and stokers, greater feed capacity is needed and this is amply provided by a suitable system of regulation.

When the rate of feeding varies spasmodically, with consequent variations in the steam delivery, the temperature of superheat also varies through a wide range. The hot gases flowing over the superheater tubes transmit to them a practically constant amount of heat, so that if the steam delivery is suddenly decreased by injecting a large volume of cold water, there is a sudden rise in steam temperature. With proper regulation of feeding there are no sudden or spasdomic variations in the feed, hence no spasmodic variations in the steam delivery; consequently, undue fluctuations in steam temperature produced by the superheater are prevented.

With open feed heaters the efficiency is increased when the rate of feed is even and not subject to wide variations. If the demand for feed water is large, due to excessive feed-valve opening, the water level in the storage space falls low and the float-operated makeup valve opens wide, introducing an excessive amount of cold makeup water with a resulting decrease in temperature. On the other hand, if the feed valves are closed too far, the makeup water is shut off, due to the high level of the water in the storage space, and steam may be wasted to the exhaust. Furthermore, if the feed valves remain closed very long the water in the heater overflows to the sewer and wastes both heat and water.

OBITUARY

FRED ULRICH

Fred Ulrich, general sales manager of the Vilter Manufacturing Co., Milwaukee, Wis., died Dec. 10, at his home, 2720 McKinley Boulevard, Milwaukee, after a short illness.

FRED ULRICH

Mr. Ulrich was born in Apolda, Thueringen, Feb. 19, 1852 He studied in the Gymnasium in Apolda, was graduated from the Royal Institute of Technology in Chemnitz, Saxony, and later from the Polytechnic Institute in Karlsruhe.

In the capacity of mechanical engineer he was engaged by several large concerns in Germany for the design, sale and supervision of large machinery installations in the Russian Empire, Finland, etc. He also traveled extensively in Italy and other countries on the Continent.

In 1882 he came to America and was connected with concerns in Cincinnati, St. Louis and Chicago, and in 1885 assumed the position of chief engineer of the Weisel & Vilter Manufacturing Co., now the Vilter Manufacturing Co. In 1888 he became a stockholder and director, and later general sales manager.

During his 29 years' continuous connection with the company he aided materially in developing the business to one of the largest establishments of its kind. In the performance of his duties he visited a great many of the ice-making and refrigerating plants in the United States and Mexico, and his wonderfully retentive memory enabled him to accurately recall small details years afterward. In the solution of all problems his highly trained, keen and observant mind was of invaluable assistance. He was thorough and conscientious in all business matters, always actuated by a high sense of honor and justice, and while generally inclined to be serious, he had flashes of dry humor which disclosed his deep insight into men and affairs. His demise is a distinct loss to his associates and the refrigerating world.

Mr. Ulrich is survived by Mrs. Ulrich, two daughters and a son.

TRADE CATALOGS

American District Steam Co., N. Tonawanda, N. Y. Bulletin No. 133. Atmospheric System of Steam Heating. Illustrated, 30 pp., 6x9 in.

American Boiler Life Co., 19 N. Market St., Boston, Mass. Pamphlet. "The Scientific Treatment of Steam Boilers and Boiler Feed Water." 8 pp., 5x8 in.

The Hoppes Mfg. Co., Springfield, O. Catalog No. 60. Feed-water heaters, purifiers, steam separators, V-Notch water meters, etc. Illustrated, 80 pp., 6x9 in.

The Direct Separator Co., Syracuse, N. Y. Catalog. Direct flanged steam fittings, American and U. S. 1915 standard, Sweet's separators, etc. Illustrated, 44 pp., 4½x7 in.

The Industrial Instrument Co., Foxboro, Mass. Bulletin No. 86. Foxboro differential recording gages and orifice meters for gas. Illustrated, 20 pp., 8x11 in. Bulletin No. 91. Foxboro thermometers and thermographs. Illustrated, 52 pp., 8x11 in.

Builders Iron Foundry, Providence, R. I. Bulletin No. 84. The Venturi meter for gravity mains, pump discharge lines, refrigerating plants, etc. Illustrated, 36 pp., 6x9 in. Bulletin No. 85. Venturi hot water meter for boiler feed, etc. Illustrated, 20 pp., 6x9 in.

BUSINESS ITEMS

The National Belt Dressing Co., 220 Broadway, New York, is placing "National" belt dressing on the market.

The pipe insulation contract for the new Utah State Capitol at Salt Lake City, for which R. K. A. Kletting was the architect, and Jas. C. Stewart Co., contractors, was recently awarded to the H. W. Johns-Manville Co., 41st and Madison Ave., New York.

Due to the death of Quimby N. Evans, the copartnership heretofore existing between Q. N. Evans, J. A. Almirall and W. C. Adams, has been dissolved and the corporation of Almirall & Co., Inc., No. 1 Dominick St., New York, has succeeded to that business.

The Goulds Manufacturing Co., manufacturer of triplex, centrifugal, hand and spray pumps, Seneca Falls, N. Y., has just opened a new office in Atlanta, Ga. The office will be located in the Third National Bank Building and will be in charge of Mr. O. B. Tanner, district manager.

A booklet which will interest every man seeking improved boiler results has just been published by the American Boiler Life Company, 19 North Market St., Boston, Mass. It tells things about scale removal, about the prevention of scale and pitting and foaming that are not only interesting but instructive. Copies are mailed on request. The title of the booklet is "Steam Boilers and Boiler Feed Water."

The Mesta Machine Co., of Pittsburgh, Penn., has recently acquired the rights from the Stumpf Una-Flow Engine Co., of Syracuse, N. Y., to build the Stumpf Una-Flow type of engine in the United States. The agreement not only gives the Mesta Machine Co. the patent rights of Professor Stumpf, but includes the use of the knowledge gained by the practical experience, during the past five or six years, of European builders of Stumpf engines. The large number of engines of this type in operation in Europe gives conclusive proof of its superiority in regard to simplicity, economy, etc.

POWER

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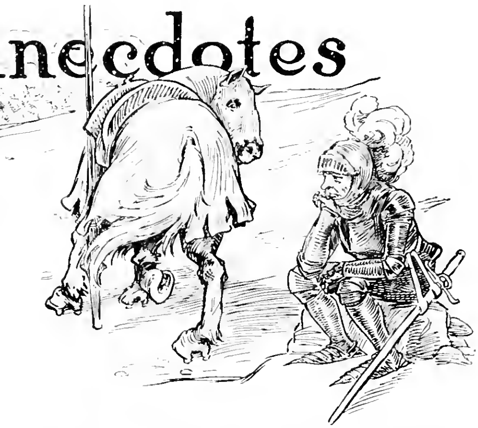
Purposeful Anecdotes



Better Be Sure Than Sorry

For the want of a nail, a shoe was lost,
For the want of a shoe, a horse was lost,
For the want of a horse, a rider was lost,
For the want of a rider, a battle was lost,
For the want of a battle, a kingdom was lost.
And all for the want of a horseshoe nail

IT IS NOT HARD to get authority to purchase a safety device after the need of it has been driven home by a sacrifice of property and perhaps life. It is another matter to convince the management of such a need where an accident never occurred.

The owner of a certain factory installed a complete system of accident-prevention appliances—at least it was intended to be complete. Every gear, pulley, belt or stairway was protected with the most elaborate devices in the market, but—

When the engineer complained that his part of the plant was being overlooked, and that if anything happened to his engine, all the machinery, protected or otherwise, would be dead, maybe for months—when he suggested this, the owner told him that he had ample protection already.

"What could happen, John?" he asked: "how could the engine run away or overspeed when it has the best governor ever invented, and you or your assistant, Charlie, are always in the engine room?"

It's hard work for some men to beat the boss in an argument, and many a good suggestion for betterment, or safety, has been lost because of lack of self-confidence—of being too timid to "talk up" to the management.

So, the subject was dropped, after the owner of the factory had, as he thought, beaten some reason into the engineer's thick head.

Then came the day when the stage was set for a first-class accident. All the conditions were perfect. The machinery had been working like clockwork; not a hitch anywhere, and the owner recalled, with a smile, the engineer's preposterous attempt to have him safeguard the engine—the engine that cost so much and worked so beautifully. John was on the third floor making some small repairs, directly over the engine room. Charlie, his assistant, sat in the old cane chair, sleepily watching the twinkling spheres of the governor as they swung after each other.

Suddenly, Charlie sat up with a jerk. The shining balls had ceased to swing and lay quiet beside the stem. But the engine was running—yes, but at what a speed. Frightened, Charlie was fascinated—lost his head, and rushed to the telephone to summon help. Before he could get the operator, a new noise caused him to drop the receiver and run for the open door. The big wheel was turning like lightning and the beautiful new engine was tugging as if it would rise from the concrete. Nobody but a madman would go near the throttle now, and Charlie was not quite a lunatic yet. Bursting into the office, he yelled "Something is wrong. Where's John?" but before the startled owner could reply, a horrible grinding noise was heard in the direction of the engine room, and the walls of the building vibrated to a shock that almost shook the men off their feet.

The flywheel had let go. Tearing their way upward and outward, through floors, heavy beams, shafting and machinery, fragments of the wheel were discharged as if propelled by guncotton. Pieces fell over a hundred yards away, demolishing everything in their path.

With pale faces and trembling chins, the two men moved cautiously to the place where the engine room used to be. Nothing could be seen because of the dense cloud of steam that roared through the broken main, but when the subsiding pressure allowed the vapor to escape through the torn roof, the owner and assistant engineer saw—and understood.

"Go and find John," said the owner. A few minutes later Charlie returned. His soiled handkerchief was pressed to his eyes. The men looked at each other.

"Did you find him?" asked the owner.

"Yes," said Charlie, in a choking voice—"Poor Jack."

Sentiment and business are not good bedfellows, and it was not long before the owner began reconstruction. The advice of the dead engineer was recalled in bitterness of spirit. The financial loss was heavy, the plant being closed for nearly three months for repairs and installing a new engine and transmission, including a fine new flywheel, bigger than the old one.

Visitors to the new power plant saw something not on the old engine which excited considerable curiosity. This was a modern, automatic engine stop, provided with connections which enabled the engine to be stopped from convenient stations located anywhere in the factory. It was arranged also to stop the engine automatically if there was any advance of speed over a prescribed maximum. Furthermore, it could be operated electrically, and one method of operation did not interfere in the least with the others.

There will never be a flywheel explosion in that plant again—at least so long as the engine stop stays on the main where the ill-fated John often wished to see it. The new man stops his engine twice daily by pressing a button, and takes pleasure in telling visitors how, when a breaking shaft once threw all the load off and the engine began to race, the engine stop lever clicked quietly once, and the steam was shut off instantly.

No engineer can tell when, or why, or how much his engine will race under certain emergencies. Governors of the usual type are probably no more reliable than the engine itself They are auxiliary safeguards, subject to their own peculiar derangements. Belts will slip and gears will clog unexpectedly, and once an engine begins to race there is only one thing to do—shut off the steam. If the engineer has nerve and happens to be there, he will close the throttle, unless the flywheel lets go first. A reliable engine stop attends to that matter whether the engineer is asleep in his bed or talking politics to the fireman in the boiler room.

(*By J. St. C. McQuilkin*)

Power Plant of American Engineering Company

SYNOPSIS—A small power plant embracing interesting features of design. The arrangement and equipment are such that the plant is easily and economically operated and provision is made for obtaining daily records of performance.

The ground plot on which the power plant of the American Engineering Co., Philadelphia, Penn., is built, is bounded on three sides by city streets. This placed a restriction which was further complicated by the intersecting streets not being at right angles to one another. The requirements were sufficient engine and boiler capacity, together with all auxiliaries and coal- and ash-storage capacity, and so arranging all the equipment that operation would be easy, convenient and economical.

Since one of the three streets contained a railroad siding, it was important to have the coal-bunker and coal-handling system convenient to the siding and also to provide space for a private siding for unloading coal.

The generating capacity of the plant is 540 kw., or 737 hp., made up of one 13 and 22 by 18-in. tandem-compound engine directly connected to a 150-kw., 250-volt, direct-current generator; two 13 and 23 by 16-in. tandem-compound engines, each directly connected to a 165-kw., 240-volt, direct-current generator; and one 12x12-in. single engine directly connected to a 60-kw., 110-volt, direct-current generator. Figs. 1 and 2 show the engine room.

In addition to the foregoing, the engine room contains the forced-draft equipment for the stokers, consisting of one steel-plate blower directly connected to either of two 5x5-in. vertical engines. All of the engines run noncondensing, the exhaust steam being used for heating the boiler feed water and also for heating the shops and offices.

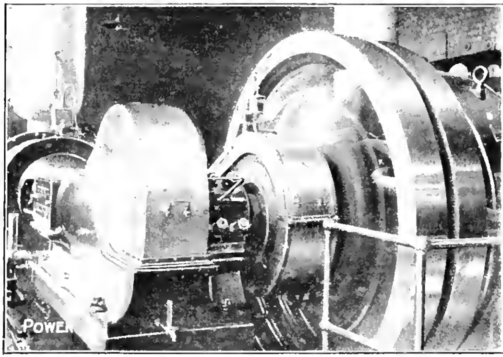


Fig. 1. One of the Main Engines and Generators in the Power Plant

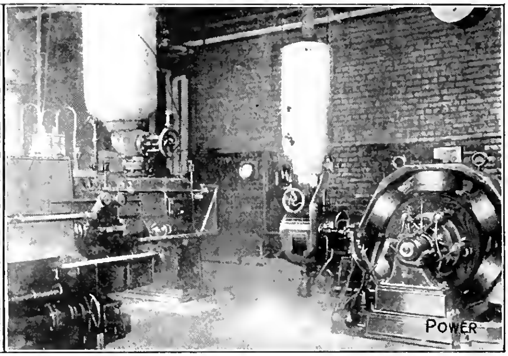


Fig. 2. The Small Unit and Steam End of a Compound Engine

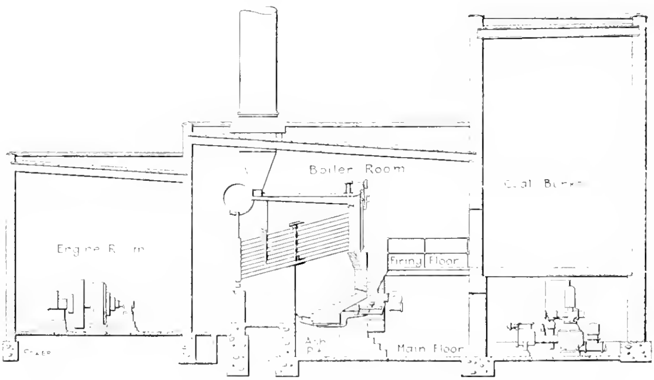


Fig. 3. Section on Line A A of Fig. 8

The boiler room has three cross-drum water-tube boilers, each having 1500 sq.ft. of heating surface and is equipped with a gravity under-feed stoker. There are also two 6 and 4 by 6-in. outside-packed duplex feed pumps, two feed-water heaters and a V-notch recording water meter (Fig. 1).

The plan of the power house (Fig. 8) shows the location of the equipment and railroad switch, and Fig. 3 shows a sectional elevation through the engine room, boiler room and coal bunkers. The compactness of this arrangement is such that there is practically no waste space, the equipment is not crowded and there is plenty of room to make the repairs and adjustments.

The combined layout of boilers, stokers, ashpit, coal bunkers, ash hoist and firing floor is interesting. The lower boiler room is practically on the street level, with the boilers and stokers so set that the lower floor is also the level at which ashes are removed from the pits.

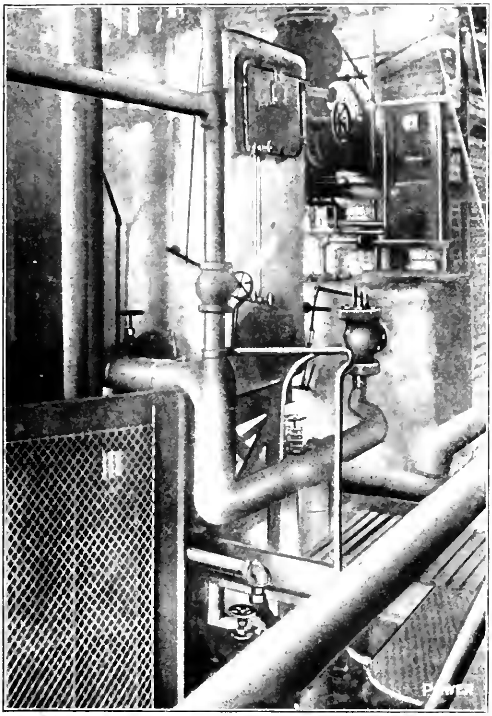


FIG. 4. FEED-WATER HEATERS AND V-NOTCH RECORDER

The upper or firing level is flush with the top of the stoker coal hoppers and is also level with the bottom of the coal bunker. The firing floor extends from the boiler fronts to the coal bunker. In the other direction, the floor is only the width of the boilers, a narrow passageway connecting the firing floor of the battery of two boilers to the firing floor of the boiler set singly.

Platform scales are built into the firing floor in front of the coal bunkers. The coal is wheeled from the bunker to the stoker hoppers, each wheelbarrow of coal being weighed and then dumped into the stoker hoppers.

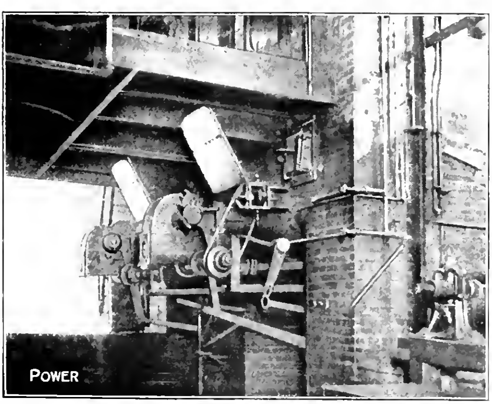


FIG. 5. STOKERS BELOW CHARGING PLATFORM

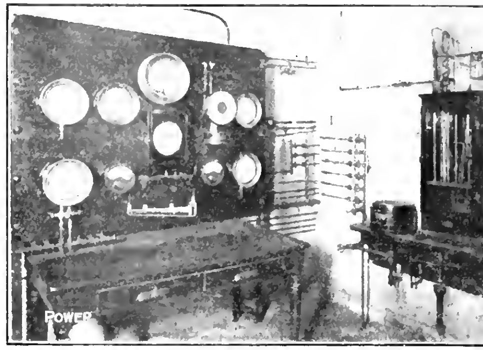


FIG. 6. RECORDING INSTRUMENTS IN ENGINEER'S OFFICE

Figs. 5 and 7 are views of the boiler room from above and below the firing floor. Slack coal is usually used and is dumped from the car through a cast-iron grating into a bucket conveyor which deposits it in the bunker. Any lumps which will not pass through the grating are broken through, making a crusher unnecessary.

The ash is wheeled to a conveyor on the same level as the ashpits and then elevated to a bunker so arranged that a truck can back under it and the ash can be discharged for final removal.

A chief engineer, an oiler and a stoker operator con-

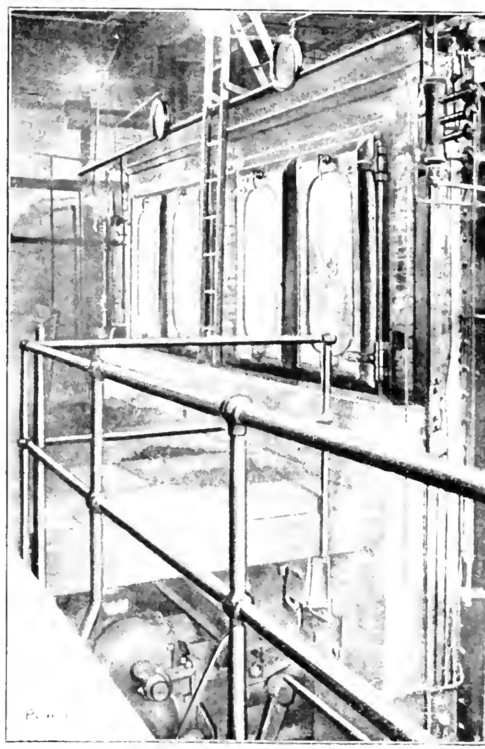


FIG. 7. CHARGING PLATFORM, STOKERS BELOW

stitute the operating force. The stoker operator tends the water, weighs the coal and removes the ashes.

The boiler gage glasses are in plain view from either the firing floor or ashpit level, and the feed valves are controlled from either floor, thereby making it unnecessary for the operator to make trips from one to the other level to regulate the water. The rate of coal feeding and the air pressure required for burning it are controlled automatically in accordance with the demands for steam, therefore the fireman is not required to continually watch the steam gage nor regulate the drafts, etc.

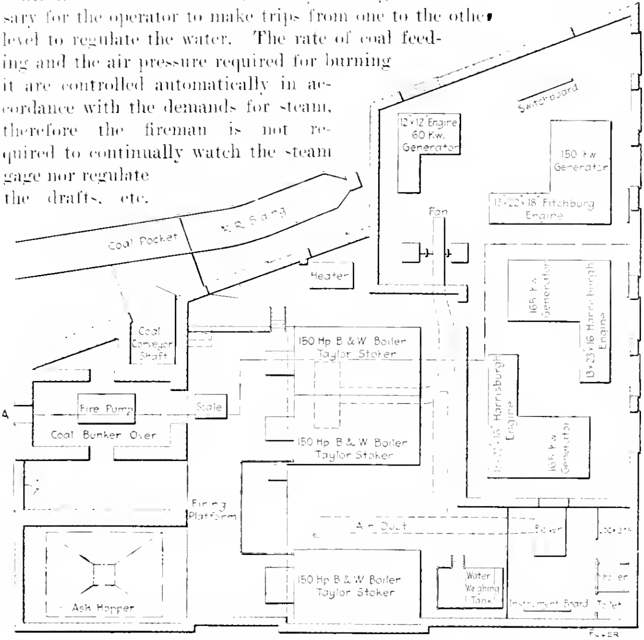


FIG. 8. PLAN OF POWER PLANT

The stoker hoppers are of sufficient capacity to give the operator ample time to remove the ashes without giving them any further attention. The plant is so compact and conveniently operated that two men could easily run it. However, since the cost of fuel is the main item of expense in any power house, it was deemed advisable to use an extra man, thereby giving the chief engineer time in the boiler room to see that the maximum fuel economy is maintained.

No. 3 boiler is equipped with an independent feed pump, weighing tanks, fan equipment and a set of recording instruments for recording simultaneously all varying conditions throughout the boiler and furnace. Thus, experimental and test work can be carried on without interfering with the normal operation of the plant. These instruments are connected to be used on any of the three boilers, thus affording the chief engineer accurate information on conditions and assisting in maintaining high economy.

The instruments, mounted on a panel (Fig. 6), are a steam-pressure gage, feed-water thermometer, air-pressure gage, differential draft gage, and flue-temperature thermometers and all the recording instruments. There are also a steam-flow meter and a recording CO_2 meter. They cover all conditions subject to variation and show graphically the relations of one to the other. All instruments are checked periodically.

In addition to the electrical load, which includes five electric traveling cranes and a fan for the foundry cupola, steam is used to drive an air compressor in the shops, for the steam hammers in the forge shop and for test purposes on the engine-test floor. From the character of the load it can readily be seen that the load has wide limits.

The steam pressure is automatically held practically constant at 160 lb. The stokers are driven from the fan shaft, and a damper regulator, connected into the main steam header, controls the speed of the forced-draft fan. The regulator operates on about two pounds' variation in steam pressure. In varying the speed of the fan, the air pressure and the rate of coal feed are controlled simultaneously. Once the correct ratio of air supply to the coal feed is obtained, no further hand adjustments are necessary.

PRINCIPAL EQUIPMENT OF AMERICAN ENGINEERING CO.'S POWER PLANT

No	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Engine.	Simple........	12x12-in	Main unit	245 r.p.m., 160 lb. steam..	Harrisburg Foundry & Mch. Co.
1	Engine.	Compound..	13x22x18-in	Main unit	225 r.p.m., 160 lb. steam	Fitchburgh Steam Engine Co.
2	Engines.	Compound..	13x23x16-in	Main unit	245 r.p.m., 160 lb. steam	Harrisburg Foundry & Mch. Co.
1	Generator.	Direct current.	60 kw	Main unit	245 r.p.m., 110 volts	Electro Dynamo Co.
1	Generator	Direct current	150 kw...	Main unit	225 r.p.m., 240 volts	General Electric Co.
2	Generators	Direct current.	165 kw.	Main unit	245 r.p.m., 240 volts	Triumph Electric Co.
2	Engines.	Vertical.	5x5-in	Fan drive	Variable speed to 146 r.p.m., 160 lb. steam.	B. F. Sturtevant Co.
1	Fan.	...		Forced draft	Variable speed to 446 r.p.m.	B. F. Sturtevant Co.
3	Boilers.	Water tube	1500 sq.ft heating surface, each.......	Main generators, one experimental	160 lb. steam, forced draft	Babcock & Wilcox Co.
3	Stokers	Taylor	..	Boiler furnace	Chain driven, automatic regulated.	American Engineering Co.
1	Meter-heater	Cochrane V-notch		Feed water	Continuous	Harrison Safety Boiler Works
1	Heater	Vacuum		Feed water.	Exhaust steam	Warren Webster Co.
2	Pumps	Duplex	6x4x6	Boiler feeders	160 lb. steam, one reserve.....	Henry R. Worthi gton
1	Recorder	CO_2 ...		Flue gas ...	Recording continuously... ...	John A. Hays
1	Recorder	Draft		Stack draft	Recording continuously... ..	John A. Hays
1	Meter	Steam flow.		Steam supply	Recording	General Electric Co.

New Composition Valve Disk

A new composition disk for steam service has been perfected by Jenkins Bros., 80 White St., New York City, and will hereafter be used in all of the company's standard pattern globe, angle, cross and radiator valves.

The disk will be known as No. 119. The composition is hard, but becomes tough and flexible in service when under steam pressure. It shows freedom from cracking and flaking and is durable with steam pressures up to 150 lb.

The Volume of Air Handled by a fan is proportional to the speed, and the power required to drive the fan varies as the cube of the speed. That is, to double the amount of air will require eight times the horsepower.

Opelousas' Municipal Lighting Plant

SYNOPSIS—The following is taken from a communication from A. C. Jones, superintendent of the municipal light and water plant of Opelousas, La., and recites some of the struggles of a small plant in a town of about 5000 inhabitants. Due to the comparatively high price of coal, and the local conditions an oil-engine plant appears to have shown considerable saving over the former steam plant.

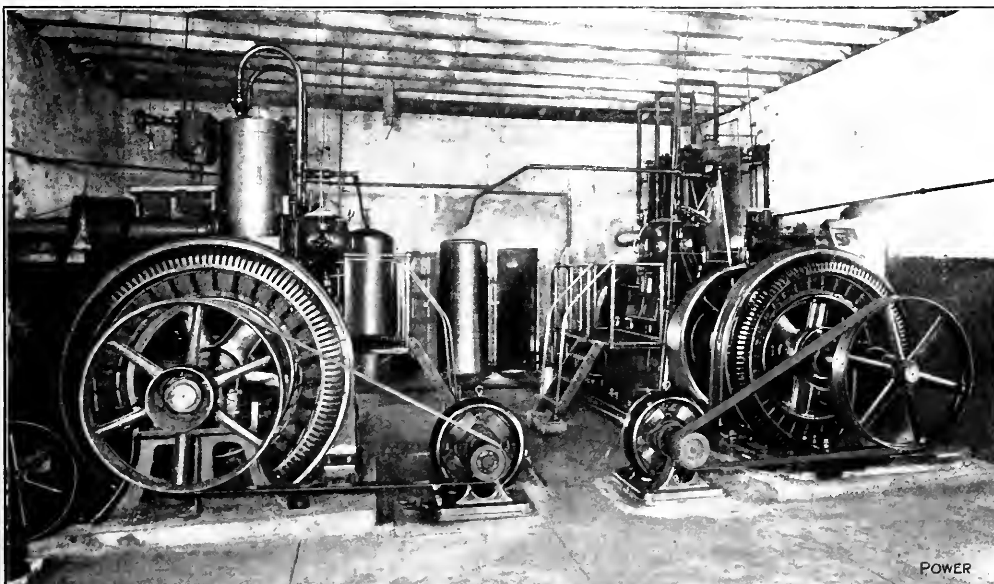
The electric-light and water-works plant was installed by this city in 1897, and consisted of one 110-hp. center-crank steam engine, two return-tubular boilers, one 50-kw. alternator, and one 40-light arc machine. There were also two water-works pumps each of 500-gal. capacity. This equipment was kept in service for a number of years and another alternator and engine were added, after which the arc machine was discarded and alternating inclosed arc lamps replaced the open arcs. This equipment gave good service and the city was able to operate it satisfactorily until about 1909 when fuel started to increase in price to a point that meant serious loss unless something was done to decrease the amount consumed. As soon as the plant started to lose more than the city could afford, the management was unable to get enough money to keep the machinery in repair. Moreover, due to local conditions, the load fell off considerably.

Finally, after spending about $1000 in repairs, a new steam plant was recommended and purchased, consisting of a tandem-compound, four-valve engine direct-connected to a 150-kw. alternator and a B. & W. boiler. This was a first-class outfit, but the results were not much better than with the old plant.

By the early part of 1911 the city finances had reached a desperate state, and it seemed that the plant would have to be shut down. The receipts from electric and water service were insufficient to pay the fuel bills, so that it had become a regular custom to borrow money from the banks to pay for fuel. The employees had to go to the banks and borrow their salaries on their own notes and at the beginning of the next year the city council would pay these notes, with interest, out of the license funds.

A new city council took charge of the city's affairs in 1912, and realizing that radical changes had to be made in the electric-light and water-works plant, arranged to increase the tax rate three mills for two years and borrowed $6000 on it. With this money there was purchased an oil-engine plant consisting of a 100-hp. Mietz & Weiss engine, direct-connected to a Fort Wayne alternator, a generator panel, a feeder panel, one 500-gal. Lawrence pump direct-connected to a 35-hp. three-phase motor, and a 12x10-in. Ingersoll-Rand air compressor with short belt drive from a 35-hp. motor. This installation cost a little over $11,000. Since the management had only $6000, it was necessary to arrange to pay out of the money collected from the electric and water service; this was fixed at $200 per month with interest.

This first unit was put into regular service in December, 1912. As it was not large enough to carry the peak load, it was necessary to run the steam plant for about three hours each night, but in spite of this the December report showed a profit of $427.82, and each month since has shown a profit.



Engine Room of the Opelousas Plant

Some time after this a second oil-engine set of 100-kv.-a. capacity was purchased, together with a 300-gal. motor-driven pump. This installation was completed Jan. 1, 1914. It cost installed $10,842, leaving a debt of $5842 on this part of the plant, which was to be paid from revenues at the rate of $250 per month with 5 per cent. interest. The plant is now paying each month $450 with interest, in addition to paying all labor and operating expenses out of collections for electric and water service. The city pays the plant $321 per month for street lighting and water service.

To improve the service the present superintendent put up 25 lightning arresters and grounded the neutral on the secondaries. This practically stopped all trouble due to lightning, which had previously been a great source of trouble. In fact, it had been customary after a heavy flash of lightning for the operator to go to the telephone and ascertain what damage had been done, so as to make repairs before dark, if the storm happened during the day time.

The water-works system is supplied with water by two motor-driven centrifugal pumps. The water in the well is 42 ft. from the surface of the ground, so that it is necessary to use an air lift to pump to the reservoir. This air is supplied by the motor-driven air compressor.

The electric service is all metered and the rates are as follows:

250 kw.-hr. or less per month, 10 cents.
300 kw.-hr. or less per month, 9 cents.
350 kw.-hr. or less per month, 8 cents.
All over 350 kw.-hr. per month, 7 cents

There is a minimum charge of 50 cents per month on 1 to 10 lights, 75 cents on 10 to 20 lights and $1 on all over 20 lights. There is practically no motor load connected except in summer for driving fans. The December load is a little over 100 kw. and the mid-summer peak load about 60 kw.

It might be mentioned that the price of oil in this locality is from $3.65 to $4 per ton and oil $1.10 per barrel, although it has reached as high as $1.55.

New Kincaid Stoker

"Fire light and often" is the injunction frequently given the fireman by the engineer who has made a study of the factors conducive to high boiler efficiency. With hand firing, the impediments to the complete success of this plan are: First, it entails more work on the part of the fireman so that he is inclined to lengthen out the intervals or, if he follows instructions, it reduces his capacity. Second, the necessarily frequent opening of the fire-door admits large quantities of excess air, reducing efficiency and tending to offset the advantages otherwise obtainable.

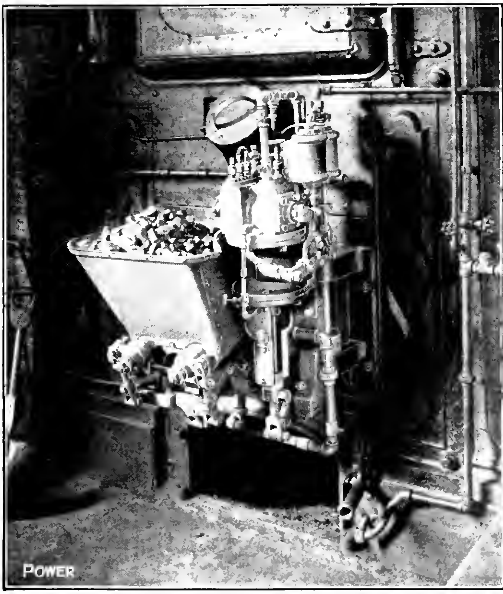


Fig. 1. Kincaid Stoker Hinged to Boiler Front

Fig. 2. Entire Stoking Mechanism Swung Free from Fire-Door

The Kincaid stoker, illustrated herewith, is designed to secure the full advantages of frequent firing of small charges while excluding the impediments just mentioned. When small charges are fed rapidly and regularly to the fire, good combustion is secured with practically any grade of fuel because the unbalanced fuel-and-air supply is eliminated. With hand-firing when fresh fuel is thrown on the grate, the air supply to the freshly covered portion of the fire is insufficient. Another difficulty is that with coal of a clinkering nature, large charges result in large clinkers. The clinkers are not only difficult to handle, but they are objectionable for the more important reason that they interfere with the uniform distribution of the air supply, which is indispensable in securing good combustion.

The stoker under discussion catapults anywhere from 3 oz. to 2 lb. of coal per charge at the rate of from 10 to 75 charges per minute, depending upon the requirements of the boiler. The coal is distributed evenly over the area of the fuel bed, as will be evident from the following description.

Fig. 1 shows the stoker in position. The apparatus is hinged on a frame bolted to the boiler front and no change in setting or boiler front is required other than the removal of the fire-door and the attachment of a fire-door frame. Being hung on hinges, the stoker may be swung clear, as in Fig. 2, for cleaning, trimming or hand-firing, should occasion arise.

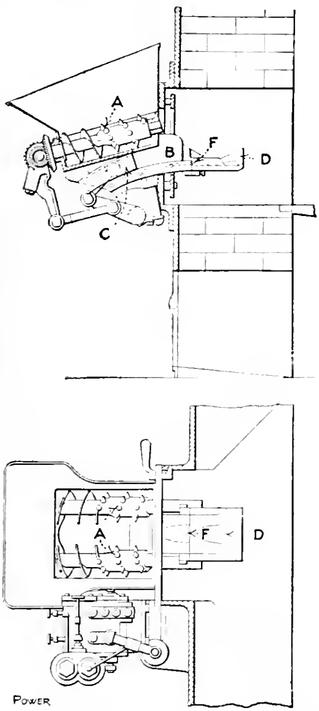


Fig. 3. Side and Top Views of Stoker, Showing Crushing Rolls and Spreading Plate

Referring to Fig. 3, the coal is fed toward the furnace in regulated quantities by means of the worms and crusher rolls *A*. The crusher rolls make it possible to use coal of any size from slack to 8-in. lumps or even mixed sizes such as mine-run, etc.

The coal drops into a rectangular space *B* in front of the ram *C*. The ram is actuated by a steam piston shown at the right of the hopper in Fig. 1. The worms *A*, Fig. 3, work intermittently so that when the ram is delivering a blow against the coal in space *B*, no coal is being fed forward. When the ram is withdrawn for the next blow, the same motion actuates the worms through a predetermined portion of a revolution. Thus, the same quantity of coal is fed to the ram for each successive blow. This quantity may be varied by changing the "throw" of the ratchet arm which turns the worms.

Steam is admitted to one side of the piston which drives the ram by means of a rapidly acting valve in much the same manner that air is admitted behind the piston of a pneumatic hammer. The acceleration of the ram is rapid, but at the end of the stroke, the piston is cushioned by a small quantity of steam trapped in the end of the cylinder so that there is practically no mechanical shock when bringing the ram to rest.

By means of a simple, adjustable throttling mechanism the pressure of the steam admitted behind the piston may be successively varied to secure strokes or blows of four different intensities. Hence, the first or weakest stroke delivers a charge of coal over the first or front quarter of the fuel bed; the second stroke delivers to the second quarter, and so on. The spreading of the coal is accomplished by means of the nozzle plate *D*.

The exhaust from the ram cylinder is led to a $\frac{3}{8}$x3-in. rectangular nozzle at *F*. The events are so timed that a blast of exhaust steam emerges from *F* at the instant that a flying charge of coal reaches the nozzle plate. Consequently, the steam catches, partly carries and assists in spreading the coal over the various portions of the fuel bed. Naturally, the intensity of the blasts of exhaust steam varies directly with the intensity of the stroke of the ram. Even spreading of the coal depends upon the contour of the nozzle plate *D*, which is varied to suit furnaces of different shapes and proportions.

The fluctuations in the demand on the boiler are accommodated by varying the number of charges of coal thrown per minute and by varying the size of the individual charge. The former method is usually employed, while the latter is resorted to only in cases of extreme variation. This change in speed is accomplished by means of a small steam pilot piston, the speed of which is controlled by a water dashpot to which it is yoked. The resistance of the water piston is varied by constructing or enlarging the passage through which the water is forced to flow from one end of the cylinder to the other. This arrangement permits of both hand and automatic control.

The stoker is manufactured by the Kincaid Stoker Co., 507 East Pearl St., Cincinnati, Ohio.

Tagliabue CO_2 Thermoscope

The Tagliabue CO_2 Thermoscope is a new device in this country, but it was fully described on p. 428 of the Sept. 23, 1913, issue of Power, as manufactured by an English company. Now it is being manufactured in this country by the C. J. Tagliabue Manufacturing Co., 18-88 Thirty-third St., Brooklyn, N. Y.

This device is used to indicate the percentage of CO_2 in flue gases. It reads directly on a plain scale and requires no correction for atmospheric conditions.

First Class Engineer almost burned his eyes out measuring between two switchboard blocks with a brass-bound rule.

Thoughtlessness—A man working on a live 2300-volt panel reached as far as he could to lay a blow torch upon the metal window casing of a reinforced-concrete building. His reach was a little short and that saved him, but the foreman saw him and gave him a week to think it over.

Draft Readings on a Stirling Boiler

By S. H. Viall*

SYNOPSIS—Deals with the importance of taking draft readings at different points in a setting and how they may be analyzed and compared with those from a standard setting.

On boilers having natural draft, the reports of many tests give the draft intensity at the stack side of the damper or at some point in the breeching, but they do not mention the available draft over the fire. With open ash-pit hand-fired boilers it is the difference in pressure between the boiler room and the furnace that tends to cause air to pass through the fuel and governs the rate of combustion and in turn the capacity of the boiler. Other information is necessary besides the draft at some point in the breeching. The arrangement of the baffling, the accumulation of flue dust or other factors that affect the size and shape of gas passages all have a bearing on the coal-burning capacity of the unit.

In the article, "Draft Loss through Boilers" (Power, June 2), valuable information on the average loss of draft intensity through different types of boiler is given. It is common to find power houses operating at capacities lower than would be available if intelligent attention were given to the draft conditions. In some plants more boilers are used than should be required, while in other plants trouble is experienced in maintaining the steam pressure.

The writer will briefly describe the work done at a certain plant and show how the information given in the article referred to can be used to advantage in analyzing conditions in other plants.

Fig. 1 illustrates the points at which draft readings have been taken in Stirling boilers operating on natural draft and giving satisfactory service as to capacity and efficiency. The average of these readings reduced to a percentage of the draft at the stack side of the damper, considered as 100 per cent., is shown by curve No. 1 of

TABLE 1—PERCENTAGE OF DRAFT AVAILABLE THROUGH STIRLING BOILER 100 PER CENT AT G

No. of Curve	A	B	C	D	E	F	G
1	4	33	41	49	68	93	100
2	3	13	23	35	48	97	100
3	3	18	52	61	77	80	100
4	4	25	35	48	60	69	100
5	4	21	36	43	57	66	100

Fig. 3, and the data are given in Table 1. This curve corresponds closely to the data given for the standard Stirling boiler, Fig. 18, on page 769 of the June 2 issue.

Fig. 2 illustrates the boiler setting at a plant which was having difficulty in generating sufficient steam to carry the load. It was known that the boiler was not overloaded and that it was clean both inside and out. The truth was that the furnace could not burn enough coal. Draft readings were taken at the points indicated. The connection between the boiler and breeching was as shown. An opening was drilled through the steel breeching connection between the damper and the boiler at the point *G*. Although this point is on the boiler side of the damper, while in Fig. 1 the corresponding point is on the stack side, the two locations are comparable on account of the loss in Fig. 2, due to a turn in the gas pass between *F* and *G* and also to the loss in taking the gases downward in the breeching. The first sets of draft

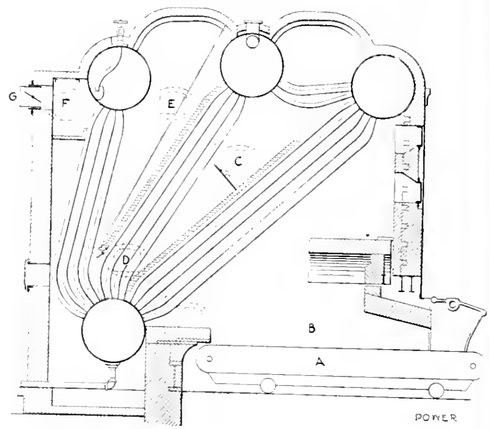


Fig. 1.

readings taken on the setting, Fig. 2, are given by curve No. 2 and in Table 1.

The loss in draft from one point of reading to another is shown more clearly by the curves than in the tables. By referring to Fig. 3, it will be observed that there is a considerable drop between points *F* and *E*, curve No. 2, as compared with the drop between corresponding points on curve No. 1; the latter is the curve for average conditions. Investigation as to the cause of this drop showed that the passage for the gases between the rear drum and the top of the baffle on the rear tubes was only 10 in. high. Tile was removed from the rear bank of tubes down to a level with the shelf at the breeching connection. This increased the opening from the drum to the shelf to 9 ft. Ordinarily this opening would be considered excessive, but as the breeching connection was a downtake of odd design to a tunnel below the floor, and as, after the change, the average temperature of the gases at *G* was only 10 deg. higher, and this with a higher rate of combustion, it is apparent that the action taken was warranted.

A second set of draft readings was taken and appears in curve No. 3. It will be noticed that the available draft over the fire is greater than in curve No. 2. The loss from *G* to *F* is greater, but the loss from *F* to *E* is small. The curve is approximately normal to point *C*, but the drop between *C* and *B* is excessive. It will be observed that the percentage of draft available at *C*, curve No. 3, is more than the percentage available for the corresponding point on the normal curve, No. 1, while at point *B*, on curve No. 3, there is less draft available than for the corresponding point on curve No. 1. This shows clearly that the restriction between these two points is greater than the average.

Further investigation showed that the baffle at the rear of the front bank of tubes was close to the front drum,

*Assistant chief of Smoke Inspection Department, City of Chicago also that the Stirling arch extended to within 4 in. of the front tubes. The gas passage between the drum and front baffle was enlarged and about 9 in. of brick cut from the arch.

A third set of draft readings was then taken, and the results are shown in curve No. 4. It is shown that the available draft over the fire is higher than in curve No. 3, also that the drop from *G* to *F* has increased. Likewise, the drop throughout the rest of the boiler has shown a slight increase except at the points on the fire side of the enlarged openings. The increase in draft loss between *G* and *F* of curves Nos. 3 and 4, as compared with curve No. 2, is due to the presence of a greater volume of gas per unit of time on account of increased coal consumption per square foot of grate. More fuel was burned by the additional air supplied to the furnace.

The drop in draft intensity from *C* to *B* on curve No. 3 is greater than on curve No. 2. The openings between these two points were of sufficient area when handling the gases produced at the lower rate of combustion. When this was increased the volume of gas was greater and the areas between *C* and *B* proved to be too small. After the conditions shown by curve No. 4 were established, there was no further change made in the baffling, because the available draft was sufficient to produce the capacity necessary to carry the load. In other words, satisfactory commercial conditions had been provided and in the estimation of the management any benefit to be realized by further work would not justify the extra labor.

Curve No. 5 is plotted from a set of draft readings taken at a later date than those of curve No. 4, but with boiler and furnace conditions as nearly the same as it was possible to reproduce them in the ordinary operation of the plant. This curve shows that draft conditions vary

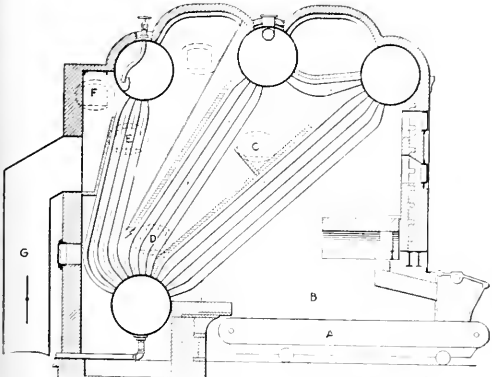


Fig. 2.

from time to time, although readings from the same plant under similar conditions will in a general way check closely.

The draft readings given for curves Nos. 2 to 5, inclusive, are not merely one set of readings, but are the average of several different observations. For example, a set of readings would be made as quickly as possible at the different points indicated. At intervals this work would be repeated until there were six or eight such sets of observations. These data were then averaged and the averages tabulated for record.

It is possible from what has been said for one to assume that all the baffling should be taken from the boiler, thereby increasing the draft intensity in the furnace to a maximum. It is true that such action might increase the fuel-burning capacity of the furnace to the utmost,

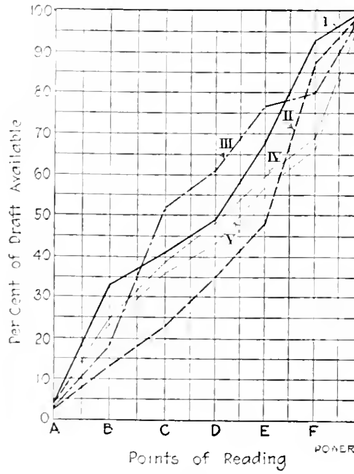


Fig. 3.

but the boiler efficiency would be low. The purpose of the baffling is to cause the heated gases to traverse the absorbing surface in such a manner as to give maximum efficiency of heat transfer. It must be borne in mind, though, that any one item in the operation of boilers can be carried to an extreme. Capacity and efficiency must be considered with relation to cost of installation, attendance, repairs, flexibility, etc. It has been found that the available draft through the average Stirling boiler with a fire 6 to 7 in. thick, using Middle Western coal with natural draft and giving satisfactory commercial returns, should be about as given in curve No. 1.

The course the writer usually pursues in analyzing draft conditions in a boiler is about as follows: Make several sets of observations of draft at the various points through the boiler. For this purpose use a draft gage constructed so that it can be read easily and accurately to hundredths of an inch. Find the average reading for each point as in Table 2. Consider the reading at the

TABLE 2—DRAFT INTENSITY THROUGH STIRLING SETTING IN HUNDREDTHS OF AN INCH WATER GAGE

No. of Curve	A	B	C	D	E	F	G	Date of Reading
2	2	8	14	21	29	58	60	Oct. 13, 1910
3	2	12	34	40	51	53	66	Oct. 20, 1910
4	2.5	16	25	31	39	45	65	Oct. 24, 1910
5	2.5	17	25	30	40	46	70	Oct. 28, 1910

stack side of the damper as 100 per cent. Calculate the ratios between the readings at the various points and at point *G*. Express these ratios in percentages as in Table 2, and construct curves similar to those shown in Fig. 3. For convenience of study, it may be advisable to make each curve a different color. Compare the curves thus found with the normal curve for the type of boiler under consideration. Draft troubles may then be quite easily corrected because quickly located.

Some Transformer Connections

By Gordon Fox

SYNOPSIS—How to determine the polarity of a transformer, connect it properly, and obtain the desired voltage combinations.

When two alternating-current circuits are to operate in parallel they must be in synchronism, which requires equality of voltage and frequency and coincidence of phase. It is not within the province of the stationary transformer to change frequencies so that only circuits of the same frequency can be paralleled. But transformers do change voltage and can easily change relative phase relations, so that where more than a single transformer is involved it is necessary to exercise considerable care to maintain the proper voltage and phase conditions.

Consider the case of two transformers connected in open delta as at *a* in Fig. 1. Here one phase is in a 60-degree relation to the other and the voltages of the secondary phases are all equal. Reversing one transformer secondary, as in *b*, changes its phase position 180 degrees, so that it now bears a 120-degree relation to the phase of the other transformer and the three secondary voltages are no longer equal.

Likewise in a three-phase three-transformer connection it is an easy matter to connect in one phase reversed: in fact, more so than with two transformers. For instance, Fig. 2-a shows three transformers of the same polarity connected properly in star and the phase relations are indicated. Reversing one of the secondary phases, an easy mistake, causes the voltage and phase relations to be entirely changed: this is shown in Fig. 2-b. Similarly, with two transformers of one polarity and the third of the opposite polarity connected as in Fig. 2-a, the phase relation of Fig. 2-b would be obtained.

The term polarity as applied to transformers refers to the relative location of the primary and secondary leads. The terms positive and negative polarity have been empirically chosen to represent the two possible relations of primary and secondary leads. A transformer is said to have positive polarity if, when a primary lead is instantaneously positive, the secondary opposite it in the case is instantaneously negative. Fig. 3-a shows diagrammatically the arrangement of coils in a transformer having positive polarity and indicates the relative instantaneous directions of the currents in the coils. This will be more evident in connection with an explanation of the test to determine polarity.

It is quite a simple procedure to test the polarity of a single-phase transformer. A voltmeter is desirable for the work but lamps can generally be used satisfactorily. The terminals are connected as in Fig. 3-b, one primary lead being connected to a secondary and the terminals *A* and *C* connected across a convenient low-tension, alternating-current line, say, 110 volts. Voltages *A-B*, *A-C* and *C-D* are then measured or their relative values determined with a lamp: If *A-C* is greater than *A-B*, the determined with a lamp. If *A-C* is greater than *A-B*, the it has negative polarity.

The polarity of transformers being determined, their relative phase relations must be kept constantly in mind when connecting them. This is best done in the case of single-phase circuits by making a rule to connect all positive polarity transformers with their leads straight and negative polarity transformers with their leads crossed. In the latter case, only one set of leads should be crossed, of course, preferably the secondaries. For the sake of uniformity it is well to adhere to a standard practice. Fig. 4 shows two transformers of positive polarity and one of negative polarity banked.

When single-phase transformers are connected on three-phase systems care must be used to preserve the proper phase relations. This can most easily be followed through if for individual cases the relative phase positions of the transformer windings are indicated on the diagram of connection. Fig. 5 represents a bank of three single-phase transformers connected in delta-star, showing the relative positions of the windings. The position of the primary windings may be arbitrarily selected, the selection being consistent with the actual physical connection. The secondary winding phase relations follow at once from the positions of the primary windings. It is then necessary only to figure the proper connection of the secondary to get the desired result.

To follow through the connections in Fig. 5, first assume that the transformers are all of like polarity; it really makes no difference whether they be positive or negative so long as they are all alike. If one transformer is of opposite polarity from the others, the same reasoning can be followed out and then the secondary of the differing transformer can be reversed. The primary three-phase wires are represented by *X*, *Y* and *Z*. Since the primary is to be delta connected, transformer No. 1 can be connected with its primary leads across any two of the primary wires; for instance, *X* and *Y*. Then the phase relation of the primary can be arbitrarily shown as designated *a-b*. Next connect the primary of transformer No. 2. These leads may be connected across either *Y-Z* or *X-Z*, the diagram showing the former. The phase relation is once more arbitrarily selected in such position that *b-c* makes a 60-electrical-degree angle with *b-a*. Next, connect the primaries of transformer No. 3. This transformer must now be connected between the wires *X* and *Z* to obtain the delta, the phase relation being represented by *a-c*, making 60 electrical degrees with *a-b* and the same with *c-b*.

In making the secondary connections, it will be best to lay out the transformer-phase relations first and make the terminal connections to correspond. For a star connection such as desired, there must be 120 electrical degrees between phases. Lay off *e-f* parallel to *a-b*. This phase makes an angle of 60 degrees with the horizontal and 30 degrees with the vertical. In transformer No. 2, *e-g* makes a 60-degree angle with the horizontal and a 30-degree angle with the vertical. By placing the points *e-e* to coincide, the desired relation is obtained between the phases of these first two transformers, namely, 120 degrees.

Next, consider transformer No. 3. This phase, graphically represented, must extend horizontally to the left, and will do so if lettered as shown. Since the points *e-e-e* form the star in the diagram they will do so in the actual connection. The leads F-G-H are the three-phase wires for the secondary circuit.

In a similar manner, a delta to delta, star to star, or star to delta connection can be laid out and connected. A little study in laying out the diagram will save time and trouble and will assure a correct connection at the first trial.

Not infrequently it is desired, for testing or other purposes, to secure a voltage other than standard. Figs. 6, 7 and 8 show three arrangements of single-phase transformers which may be used in emergencies or for special purposes. Fig. 6 shows an auto-transformer connection for securing a 10 per cent. boost in the line voltage. Fig. 7 is a step-down arrangement providing a higher secondary voltage than that resulting from the ordinary transformer connection. In this case half the secondary is connected bucking the primary, thus reducing the effective primary turns and decreasing the ratio of transformation proportionately. The capacity of the transformer is cut nearly in two since only half the secondary is available to carry secondary load. In the case cited, with a ratio of transformation of 5 to 1, the voltage across one-half the secondary would be 110 with the usual connections; whereas, with the connections shown, it would be 122. Where the ratio of transformation is high, the difference would be small. A connection similar to that of Fig. 7, in which half the secondary is made to boost the number of effective primary turns, would change the transformation ratio so that a voltage of 100 would result in the other secondary coil, providing the original ratio was 5 to 1 and the primary voltage remained the same.

Fig. 8 is an arrangement utilizing two transformers with the primaries in parallel and secondaries in series to give double the rated voltage of the transformer secondaries. An arrangement of this sort could be easily made to utilize transformers on hand in a plant where an increase in voltage is desired.

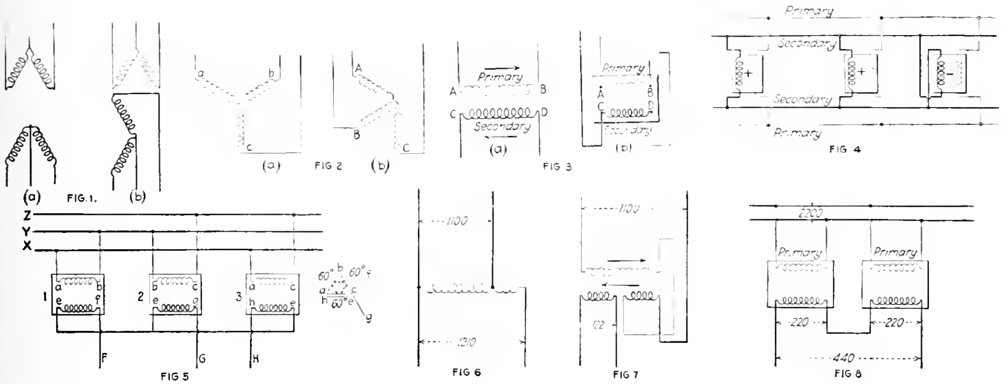
Sometimes in connection with three-phase work it is desirable to obtain a range of voltage. This can be done within certain limits by manipulating the connections. With a given primary connection the secondary star connection provides 1.73 times the voltage from the delta connection. By changing both primary and secondary for both arrangements and utilizing various combinations, quite a flexible and broad voltage range is attainable.

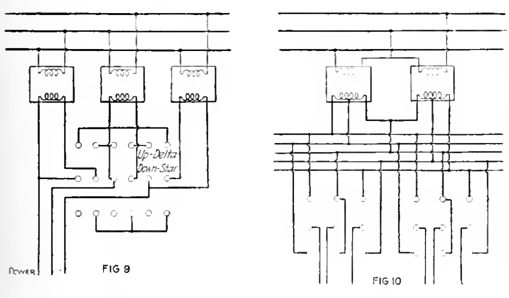
Assume three single-phase transformers with 2300-volt primary windings and 115-230-volt secondaries. The table shows the number of available three-phase secondary voltages which can be secured by different connections. If the transformers are provided with 10 per cent. taps, as most standard transformers now are, the range can be still further enhanced. With such a number of connections it may appear difficult to make the necessary changes. Fig. 9 shows a switch arranged to make it possible to change easily from star to delta and *vice versa*. A little study will make the connection plain. By providing such a switch in both primary and secondary circuits the changes can be quickly made.

TABLE OF TRANSFORMER CONNECTIONS

Primary Connection	Secondary Connection	Primary Volts	Secondary Volts	Remarks
Star	Open delta	2300	66 or 115	Using middle taps of two transformers.
Star	Star	2300	115	Using all middle taps.
Star	Delta	2300	133	Outside terminals.
Delta	Star	2300	199	Using all middle taps.
Delta	Delta	2300	230	Outside terminals.
Delta	Star	2300	398	Outside terminals.

One case in which an arrangement of this kind sometimes proves useful is to provide reduced starting voltages for motors. If there be but a single large motor fed from a transformer bank, it may be feasible to do away with an expensive compensator by simply connecting the transformer secondaries in delta at starting and then throwing over to star for running. The ratio of torques compares with the lowest point on ordinary com-





VARIOUS TRANSFORMER COMBINATIONS

pensators. This arrangement is not suitable where more than one motor is involved. Another arrangement which can be used for a number of motors is shown in Fig. 10. This is merely an open delta in which the 50 per cent. taps are used to secure the lower starting voltage. Since the starting torque of motors at 50 per cent voltage is low, this arrangement cannot be used where heavy starting duty is required. The additional wiring may prohibit its use for an extensive system, but in not infrequent cases it can be, and is, used to advantage.

Lack of Synchronism in Check-Valve Action

By S. F. Jeter

In the changes in the Massachusetts boiler rules, as given in the issue of Sept. 15, p. 395, under Section 2, paragraph 25, it is proposed to require a separate check valve on the return pipe to each boiler instead of one check valve on the main return pipe, as is now the rule.

Such a change would certainly be a step in the wrong direction, for it has been amply demonstrated in practice that check valves arranged in parallel cannot be expected to act in synchronism under small differences in pressure. The failure of these valves to act in unison is due to a tendency to bind and a slight difference in the weight of the valves where they are of the same size; but chiefly due to the differences in area exposed to pressure on the two sides of the valve produced by the difference in the amount of seated area in valves of the same size. In the case of valves of different sizes the difference in the ratio between the seated and the effective area under the valve causes the failure of such valves to act in unison. I recently observed a case of trouble resulting from this cause, which aptly illustrates the difficulties that may be expected if this change is made in the rules.

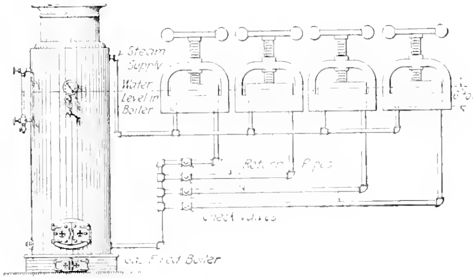


Fig. 1. The Original Installation

An establishment which required heated platens for a series of presses had an automatic gas-fired boiler to furnish the steam during the summer months in place of the larger boiler. The original arrangement was as shown in Fig. 1, where the normal water line in the boiler was about six to eight inches above the steam spaces in the presses. It was advised that there should be installed a pump or some form of lifting trap (since it was impractical to lower the boiler) in order to get steam into the platens of the presses, as was required. A tilting trap was installed (Fig. 2), but the apparatus failed to operate properly. The trouble was that the water line in the boiler would drop rapidly and get entirely out of sight in the glass, which would necessitate closing down, as the boiler's water capacity was limited. Any tendency of the water stopping at any point in the system would lower the water line to a dangerous point.

It was decided that the check valves on the returns did not act in unison and that water collected in one or more of the platens due to the failure of the check valves to open. The separate return pipes were replaced with a single pipe and check (Fig. 3) and the trouble was removed. The distance from the bottoms of the platens to the level of the return pipes where the check valves were

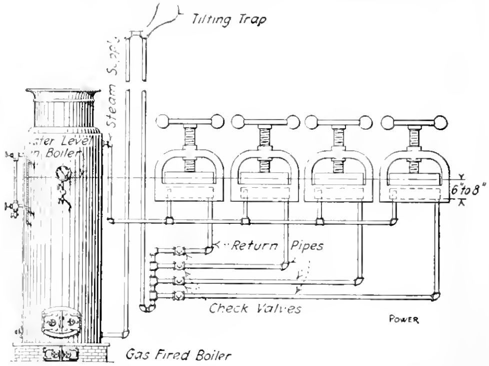


Fig. 2. First Connection to Trap

located was about fourteen inches, which clearly demonstrated that these particular check valves, which were all of the same size and make and were purchased at the same time, could not be relied on to work nearly enough in unison to prevent a change in water level of fourteen inches. No water could begin to collect in the platens until this difference of level was maintained by one or more of the check valves failing to operate under this head.

Differences of water level considerably less than the above would be dangerous in many kinds of heating boilers. Of course, with a single check valve for several boilers there is the risk that the attendant may close the steam valve on a boiler without closing the stop valve on the individual return pipe to the same boiler, but that danger is less than the danger from the condition mentioned. A better arrangement than either would be to have the return connections located at or above the lowest safe-water line, as was suggested in the issue of July 28, p. 133.

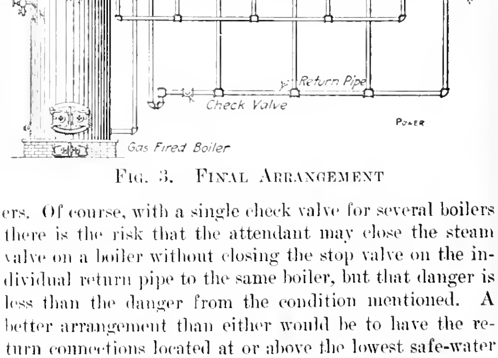


Fig. 3. Final Arrangement

Standard Iron Co.'s Steam-Turbine Power Plant

By O. C. Thomas

SYNOPSIS—The charcoal-iron manufacturing plant of the Standard Iron Co., Ltd., is on an inlet of Georgian Bay, at Perry Sound, Ont. The power house is of interest in possessing a turbo-blower and in the variety of purposes to which steam turbines have been applied. Although furnace gas was available, the convenience of gas-fired boilers and the direct rotary drive of steam turbines, together with ease of starting up, made turbines preferable to gas engines.

The steam generators of this plant, Fig. 1, consist of three flush-front, horizontal return-tubular boilers having furnaces designed for either coal or blast-furnace gas. Each boiler is rated at 200 hp. and has 2000 sq.ft. of heating surface; the shell dimensions are 78 in. diameter by 20 ft. long. The boilers are designed for a working pressure of 150 lb., in accordance with the Massachusetts boiler rules. The products of combustion are discharged into a 5-ft. diameter, 125-ft. guyed stack.

Steam Turbo-Blower

For supplying air blast to the furnace a turbine-driven blower is employed with a capacity of 12,000 cu.-ft. of free air per min. delivered at from 6 to 8 lb. per square inch and running at 4000 r.p.m. All bearings are fitted with forced lubrication, oil being delivered from a gear pump driven from the main shaft and circulated through an oil cooler and filter before being returned to the bearings.

Air is taken in through a 1/4-in. mesh wire-gauze screen and filter outside the building and carried in a duct under the turbine-room floor to the blower. There are nonreturn and relief valves in the air main to the furnace. The turbine end of the blowing unit consists of an impulse steam turbine, taking saturated steam at a boiler pressure of 150 lb. and exhausting into a low-level jet condenser at 28-in. vacuum, referred to 30-in. barometer. The steam consumption is 13.9 lb. per brake-horsepower-hour. Noncondensing working is provided for by a 10-in. "Multiflex" atmospheric relief valve and a gate valve for isolating the condenser. A steam separator is placed between the turbine and the lowest point in the main steam header. The overall dimensions of the turbo-blower are 5 ft. and 15 ft. by 6 ft. 2 in. in height from the bottom of the bedplate.

For driving the removal pump of the jet condenser, a 14-hp. steam turbine is used, running at 1850 r.p.m. The condenser is placed in a basement below the turbine to facilitate the flow of injection water. The vacuum is maintained by an engine-driven dry-air pump, shown at the left of Fig. 1.

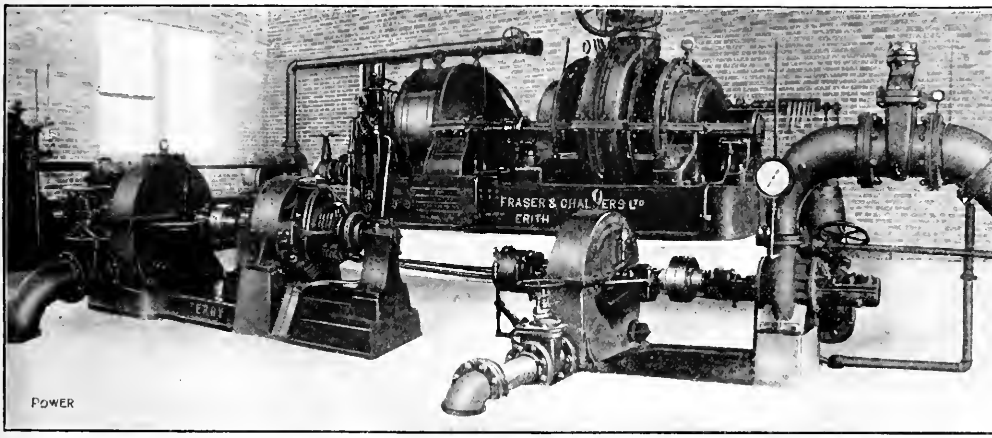


Fig. 1. Turbine-Driven Blower, Generator and Condenser Water-Removal Pump

Electrical and Pumping Equipment

Other apparatus in the power house includes a 40-kw. turbo-generator for lighting and power purposes, one 5- and one 8-in. turbine-driven centrifugal pump, two duplex outside-packed boiler-feed pumps, and a closed feed-water heater, through which the auxiliary units exhaust their steam. The 40-kw. direct-current generator runs at 2800 r.p.m., being driven by a noncondensing steam turbine taking 37½ lb. of steam per brake-horsepower. The 5- and 8-in. centrifugal pumps driven by turbines are for general service and deliver cooling water to the furnace.

The 40-hp. turbine driving the 5-in. pump takes 1500 lb. of steam per hour noncondensing. These pumps, together with the condenser, draw their water from a 14-in. suction main running from the bay, 256 ft. from the power house. The lake-water level is 15 ft. 6 in. below the centrifugal-pump centers and 13 ft. below the condenser-injection inlet. The pumps are primed by a steam ejector.

The two duplex feed pumps have normal capacities of 108 gal. per min. each and are situated in the boiler room; they are arranged to draw water either from the condenser hotwell or from the main centrifugal pump-suction line. The feed-pump discharge is led through the feed-water heater on its way to the boilers, a bypass cutting out the heater for cleaning, etc.

Steam is conducted from each boiler by a 6-in. branch and an isolating valve leading into a 6-in. steam main to the turbine room, where, by a vertical drop of 17 ft., the pipe passes to the level of the trenches in the concrete floor, through which the branches to the different units are led. The vertical length of main does away with any necessity for an expansion bend and facilitates

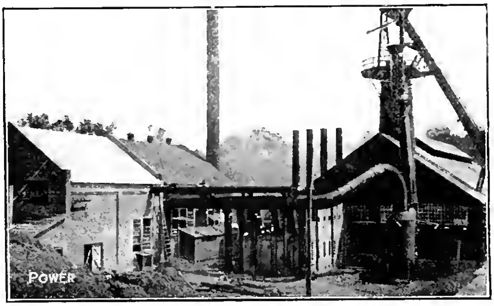


Fig. 2. Power House and Piping to Furnace

drainage, which is designed to gravitate toward the steam separator. Water of condensation is removed by an automatic steam trap directly attached to the separator. Although steam piping in trenches is not usually advantageous, the fact that in this instance all the turbines are placed above the piping renders remote the chance of damage by water. The high-pressure main and branches above 2½-in. in diameter are of extra-heavy, wrought-steel pipe with screwed-on flanges. For 2½-in. diameter and less, screwed fittings are used.

The blower turbine is connected to the condenser by a cast-iron exhaust bend and a corrugated copper expansion joint. All the other units exhaust into a galvanized wrought-steel exhaust main connected to the feed heater. Isolation of the heater is attained by closing a gate valve next to the heater and opening another on the exhaust main leading to the atmosphere. These valves will also be used in cold weather to build up a slight back pressure for exhaust-steam heating. A relief valve is fitted to the main in a conspicuous position to draw attention to any undue rise in pressure.

The water connections to the centrifugal pumps and condenser are of cast-iron flanged pipe with long-radius elbows, and taper pipes make connections with the pump branches. The main suction line is of flanged piping, and was tested for air leaks to a pressure of 30 lb. per sq.in.

In addition to a necessary foot valve at the intake, check valves are placed in the branches to the condenser and feed pumps, and there are water-sealed gate valves in the branches to the centrifugal pumps. The velocity of water in the suction main under normal operating conditions is 280 ft. per min., and the friction head loss between the lake and the pumps is estimated at about 2.7 ft., omitting the resistance of the foot valve.

A solid rock formation immediately below the engine-room floor made it inexpedient to place the power house at a lower level, and prohibited the construction of an intake flume. The satisfactory working of the present arrangement shows that any other scheme would have been an unnecessary expense. The feed piping to the boilers is extra heavy, similar to the main steam piping, and each branch to a boiler has the usual stop, check and feed-regulating valves, the latter arranged at the front of each boiler at hand level. With two exceptions, all water and feed valves are of the straightway type.

The plant was started up and the blast furnace, Fig. 2, "blown in" on Aug. 21, 1913, and on Aug. 24 the furnace was tapped and several tons of charcoal pig-iron drawn off. The simplicity of operation of this power plant is worthy of comment. In the first place, the boilers are gas fired and therefore need but little attention. The only reciprocating motive power is that driving the air pump, and it is automatically oiled. As the rest of the apparatus is steam-turbine driven, the whole plant can be easily operated by one man, and his duties are practically limited to watching the feed water and keeping the log book entered up.

The contractors for the equipment were the Rudel-Belknap Machinery Co., Ltd., Montreal; the turbines were supplied and erected by Fraser & Chalmers of Canada, Ltd., Montreal.

Tricks of the Trade

By F. W. Harris

Thompson was a passenger- and freight-elevator salesman selling both hydraulic and electric elevators. He not only sold elevators for new buildings, but he would sell an electric to replace a hydraulic elevator, giving incontrovertible reasons to justify the change. He would also sell a hydraulic elevator to replace an electric, and give equally solid data to justify this change. In fact, he was a true salesman.

He had been after old John True for a long time to get him to throw out a "worthless" hydraulic machine and put in an electric, and he was spurred on by the fact that he had a customer who had a "worthless" electric elevator which he planned to replace by a hydraulic.

Thompson found, by spending a little money on cartage and erection and furnishing a little additional material, that the shift could be made with profit to himself and temporary satisfaction to both customers.

Old John operated his hydraulic elevator from the city water mains and Thompson visited the water bureau.

"I am from True & Sons," he stated. "We have mislaid our bills for the last two years and I wondered if I could get a statement of the amounts for these years."

He found that the bill for two years was $195. Old John refused to be convinced by his arguments and particularly scouted the claim of lower cost for the electric. "You don't know what it costs me to run my elevator," he objected; "you are just guessing at it."

"Not exactly guessing, Mr. True. We elevator men can figure closely. Now, I know the distance you have to lift and I can give a close estimate of the average load carried and the number of trips made per day. I know the water rate in this city and the rest is a mere matter of higher mathematics."

Old John looked at him over his glasses and growled: "Higher mathematics, eh! And what do you make it by your higher mathematics?"

"Well, considering general business conditions during the last two years, your water bill should have been a little under $200 for the two years; say $195."

"Wait a minute until I get the bills."

The old man went over the file slowly and finally came back with two bills which he totaled. Then he looked over his spectacles at Thompson with a new respect in his eyes.

"Say," he said, "you are surely a close figurer. It cost exactly $195."

Whereupon Thompson got out his orderbook.

Small Isolated Plant Pays Big Dividends

By Thomas Wilson

SYNOPSIS—This small plant, which is earning from 17 to 21 per cent. on the original investment after fourteen years of service, is equipped with high-speed engines and practically all of the exhaust steam is utilized.

From central-station sources it has been frequently stated that the commercial life of a plant should be limited to fifteen years. There is no doubt that some plants are ready for the scrap pile at the end of this period and that others might better be equipped with more efficient machinery, but in the majority of isolated plants the time of usefulness and efficiency far exceeds the limit named. This is particularly true where heating is to be done. Where there is use for the exhaust steam the engine rate is not of prime importance, for if the supply of exhaust is curtailed, live steam from the boilers must fill the demand and the total is as high as ever.

A plant which has been in use for fourteen years in a

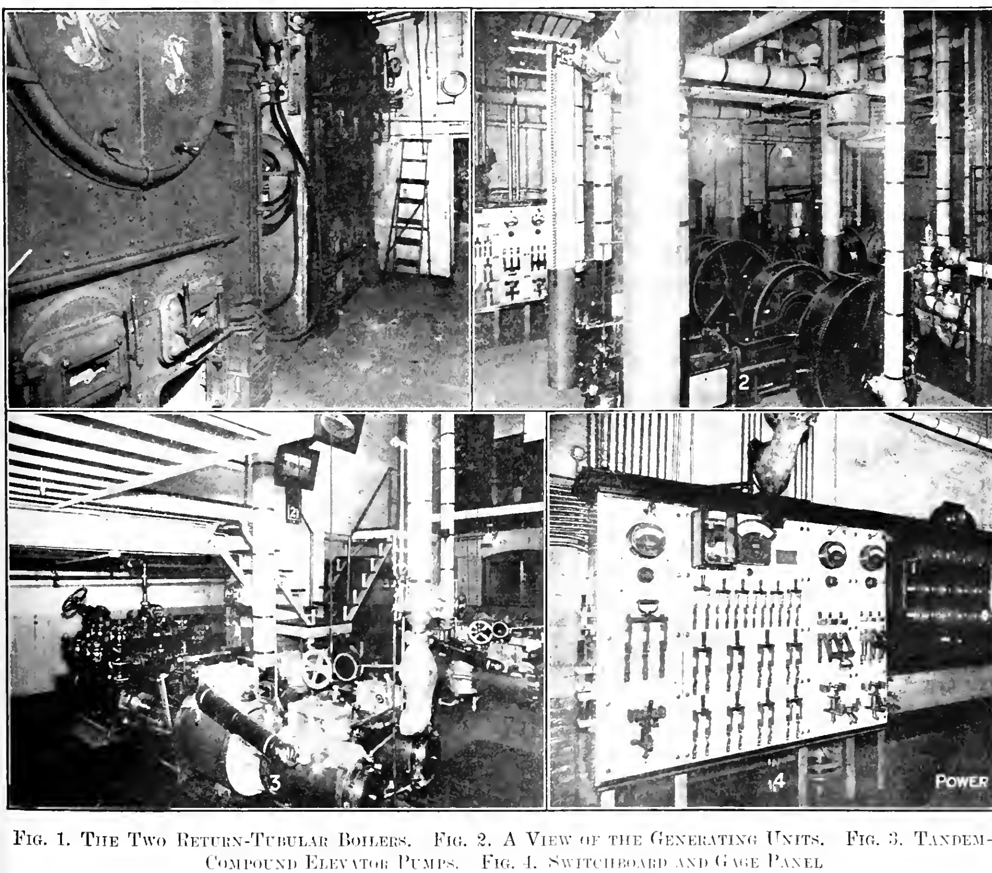


Fig. 1. The Two Return-Tubular Boilers. Fig. 2. A View of the Generating Units. Fig. 3. Tandem-Compound Elevator Pumps. Fig. 4. Switchboard and Gage Panel

Northern city and is good for as many more is here described. The casual observer would think that the plant is only four or five years old as the engines, pumps and accessories have the freshly painted appearance of being new and are in the best of condition. Besides, an examination of the records shows that the plant is as efficient as many of more recent design.

The firm does a wholesale hardware business, and makes harness, awnings, tents and does some forge work. It has two large frame buildings from two to eight stories high. In plan, the main building measures 420 ft. on one side, 450 ft. on the other and is 100 ft. wide. The other building is 125x140 ft.

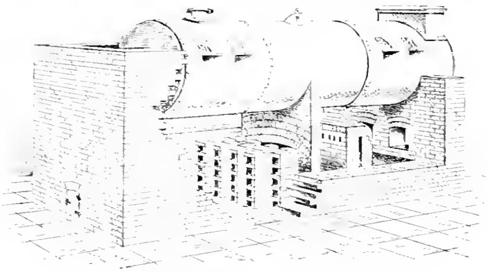


Fig. 5. Type of Boiler Setting Used

The equipment consists principally of two 72-in. by 20-ft. tubular boilers; two 75-kw. direct-current dynamos, each driven by 11x18x14-in. tandem-compound engines running at 270 r.p.m.; one simple 11x12-in. engine driving a 45-kw. machine at the same speed; two feed pumps, one a 7x4¾x8-in. duplex and the other a simplex, 7⅝x4½x9-in.; one duplex 18x10x12-in. fire pump; two 12x4½x18-in. tandem-compound duplex elevator pumps and six hydraulic elevators operated under an oil pressure of 800 lb. in connection with an accumulator. Four of the elevators are rated at three tons, one at one ton and the other at 1500 lb. There are also some locomotive-type air compressors, a 5¼x4¾x5-in. duplex house pump, one 8x12x12-in. vacuum pump, a feed-water heater and some minor equipment.

The fire-tube boilers (Fig. 1) are 6 ft. in diameter and 20 ft. long, have seventy 4-in. tubes and the joints are of the butt-and-strap type. Under an operating pressure of 125 lb., they have been worked for the fourteen years with only minor repairs. The water, obtained partly from driven wells and from a bay, is of good quality, and a small amount of compound, costing about $25 per year, has been used to keep the boilers clean. One boiler, forced at times above rating, carries the load except during the coldest weather. Under the boilers are shaking grates measuring 6x5 ft. To the grate surface of 30 sq.ft., a heating surface of 1740 sq.ft. bears a ratio of 58 to 1. The breeching is of uniform size, 4 ft. square, and enters a rectangular brick stack, 7x4 ft. and 140 ft. high. To the connected grate surface the area of the breeching bears a ratio of 1 to 3.75 and the stack area a ratio approximating 1 to 2. It is evident that the cross-sections of both breeching and stack are abundantly large, but no doubt some allowance has been made for the higher resistances of square passages.

Semibituminous egg coal is delivered by rail and dumped from cars on a siding into a hopper underneath the track. It is raised by a chain belt of home manufacture to a bin in front of the boilers and hand-fired onto the grates. There are two doors to each furnace and the alternate method of firing is used.

The furnace is of the special design shown in Fig. 5. It consists first of a hollow bridge-wall with an opening leading out under the grate. Near the top and at the back of the bridge-wall heated air passes out through a series of openings to mix with the gases of combustion and supply sufficient oxygen for the volatile. In the firing doors there is provision for admitting air over the fire; the boilers are operated with the ash doors removed. Back of the bridge-wall and extending down from the boiler shell is an arch under which the gases must pass into a checkerwork of brick piers. The latter maintain a high temperature in the combustion chamber so that the gases, mixed thoroughly in their passage under the arch and among the piers, burn at a high rate of combustion.

Water for the boilers in the heating season comes from a tank receiving the returns of the heating system. By means of a ball and float, makeup water is supplied from the house tank on the seventh floor. Duplex-feed pumps force the water to the boilers through a vertical closed heater 30 in. diameter and 12½ ft. high and a single-pipe economizer in the breeching 2 in. diameter and 60 ft. long. In the heater the temperature of the water reaches 150 deg. and is raised to 204 by the economizer. That the latter has been in service nine years and is still in good condition is attributed to the fact that the water enters the pipe hot (150 deg. at least), so that there is no opportunity for sweating and collecting pasty masses of soot on the exterior.

Heating is required nine months in the year from the 23,500 sq.ft. of radiation. The smaller building has a two-pipe system with a vacuum pump at the end of the line; the main building has a single-pipe Paul system.

DAILY REPORT OF POWER PLANT

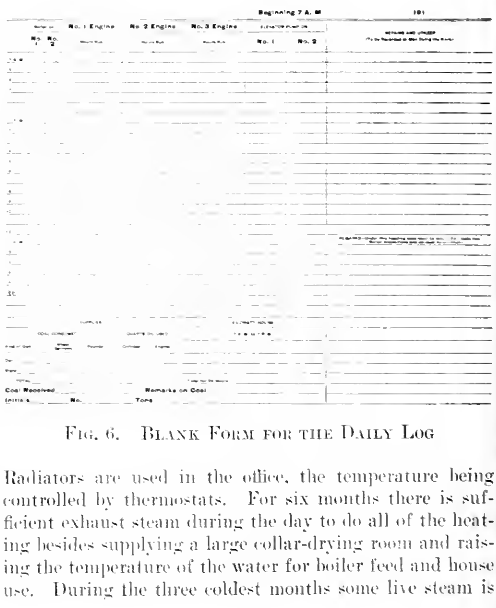


Fig. 6. Blank Form for the Daily Log

Radiators are used in the office, the temperature being controlled by thermostats. For six months there is sufficient exhaust steam during the day to do all of the heating besides supplying a large collar-drying room and raising the temperature of the water for boiler feed and house use. During the three coldest months some live steam is required, and at night throughout the cold season it is necessary to draw on the boilers, as the load is always light and the supply of exhaust steam is limited. The conditions then are unusually favorable. For nine months in the year, all of the exhaust steam is utilized and during the remaining three months part of the available supply goes to the feed-water heater, the drying room and the hot-water tank.

For ten hours the load averages about 650 amp., although it fluctuates considerably, due to the throwing on and off of some of the larger motors. After 10 o'clock at night and on Sundays it is only nominal. The connected load is 130 motors, these totaling only 208 hp., as many of them are used on sewing-machines, stitchers, envelope-sealers, adding machines, etc., and consequently are of small size. All operate at 110 volts and with the exception of a few shunt machines are compound wound.

For illumination there are, in round numbers, 5000 sixteen-candlepower lamps.

It has been the custom to run one of the compound-engine units for the greater part of the day. From 3 to 5:30 p.m., during the peak load, and on dark days the simple engine is used to help out, and after 10 in the evening it is the only engine running.

TABLE 1. POWER PLANT EXPENSES AND EARNINGS AT CURRENT RATES FOR 1911

Expenses

Coal, $3.45 per ton	$4,653.57
Switching and unloading	180.00
Engine oil used for all purposes	10.00
Cylinder oil	86.36
Grease for engines and motors	1.05
Hydraulic oil for elevators	56.52
Waste for engines, elevators and motors	56.52
Engine repair	70.81
Boiler repair	7.55
One-half of chief engineer's salary	800.00
Second engineer's salary	1,033.75
Two firemen's salaries	1,678.90
Paint and varnish	6.00
Fixed charges: Interest, 5%; depreciation, 5%; insurance and taxes, 1% on plant cost of $30,000	3,300.00
Total expenses and charges	$11,971.03

Earnings

Current at 3c. per Kw.-Hr.	Kw.-Hr.	
January	23,423	$702.69
February	18,950	568.50
March	22,710	681.30
April	20,097	602.91
May	20,090	602.70
June	17,204	516.12
July	18,343	550.29
August	20,612	618.36
September	18,327	549.81
October	20,823	624.69
November	20,427	612.81
December	23,423	702.69
Total	244,429	$7,332.87
Heating; 23,500 sq.ft., at 30c.		7,050.00
Six hydraulic elevators, 300 working days, at $7 a day		2,100.00
Water pumped at 2c. per 100 cu.ft.		504.00
Fire pump maintenance for one year		78.00
Live steam to factory		56.00
Hot water for house service		78.00
Total earnings		$17,198.87
Total expenses		11,971.03
Net earnings		$5,227.84

TABLE 2. POWER PLANT EXPENSES AND EARNINGS AT CURRENT RATES FOR 1912

Expenses

Coal, $3.45 per ton	$5,111.13
Switching and unloading	211.50
Engine oil used for all purposes	52.61
Cylinder oil	83.60
Grease for engines and elevators	4.20
Waste	35.41
Boiler compound	25.70
Boiler repairs, brick setting	95.40
No. 2 engine overhauled	195.60
Other repairs	32.88
Packing for engines and elevators	9.29
Paint for engine room	20.26
Metal polish	0.72
Tools	8.50
Half of chief engineer's salary	850.00
Second engineer's and two firemen's wages	2,623.77
Fixed charges: Interest, 5%; insurance and taxes, 1%; depreciation 5% on plant cost of $30,000	3,300.00
Total expenses and charges	$12,660.87

Earnings

Current at 3c. per Kw.-Hr.	Kw.-Hr.	
January	28,327	$849.81
February	25,047	751.41
March	25,650	769.50
April	24,337	730.11
May	25,167	755.01
June	22,563	676.89
July	23,783	713.49
August	25,390	761.70
September	26,590	797.70
October	26,270	788.10
November	26,270	788.10
December	27,243	817.29
Total	306,637	$9,199.11
Heating; 23,500 sq.ft., at 30c.		7,050.00
Six hydraulic elevators, 300 working days, at $7 a day		2,100.00
Water pumped for building at 2c. per 100 cu.ft.		504.00
Fire pump maintenance for year		78.00
Live steam to factory		100.00
Hot water for house service		80.00
Total earnings		$19,111.11
Total expenses		12,660.87
Net earnings		$6,450.24

PRINCIPAL EQUIPMENT OF THE ISOLATED PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Fire-tube	72-in x20-ft	Generate steam	Natural draft, hand fired, 125 lb. gage	Northwestern Boiler Wks.
2	Furnaces	Reekie smokeless		Under boilers		J. D. Reekie of Duluth
2	Grates	Shaking	6x5-ft	Under boilers		Beck
1	Heater	Inclosed vertical	30 in. dia., 12½ ft. high	Heat feed water	Exhaust steam, water 150 deg.	Kewanee Boiler Co
1	Pump	Duplex	7x4¾x8-in	Boiler feed water	125 lb. steam	Fred M. Prescott Steam Pump Co.
1	Pump	Simplex	7¾x4½x9-in.	Boiler feed water	125 lb. steam	Union Steam Pump Co.
1	Pump	Simplex	8x12x12-in	Vacuum on heating system	125 lb. steam	Union Steam Pump Co.
2	Pumps	Tandem comp. duplex	12x4½x18-in	On hydraulic elevators	125 lb. steam	Fred M. Prescott Steam Pump Co.
1	Pump	Duplex	18x10x12-in	Fire	70 r.p.m., 125 lb. steam, 1000 gal. per min.	Fairbanks Morse & Co.
1	Pump	Duplex	5¼x4¾x5-in.	House pump	125 lb. steam	Gardner Governor Co.
6	Elevators	Hydraulic	Four 3-ton; one 1-ton, one 1500 lb.	Passenger and freight	Oil pressure 800 lb., 150 ft. per min.	Otis Elevator Co.
1	Pump	Duplex	4½x2¾x4-in	Oil for elevators	125 lb. steam	Fred M. Prescott Steam Pump Co
1	Air compressor	Simple, locomotive type	9x6½x9-in	Air chamber of elevator system	Steam 125 lb., air 150 lb.	Westinghouse Air Brake Co.
2	Engines	Tandem compound	11x18x14-in	Main units	Steam 125 lb., 270 r.p.m.	A. L. Ide & Sons
2	Generators	Direct-current	75-kw	Main units	115 volts, 270 r.p.m.	General Electric Co.
1	Engine	Simple	11x12-in	Main unit	125 lb. steam, 270 r.p.m.	A. L. Ide & Sons
1	Generator	Direct-current	15-kw.	Main unit	115 volts, 270 r.p.m.	General Electric Co.

Fig. 6 illustrates the daily report sheet used at the plant. The accompanying tables show the operating costs for 1911 and 1912 under the conditions just enumerated and the earnings when charging current rates for the same services. In computing the expenses only half of the chief engineer's salary was charged, as but half of his time is devoted to the plant. The fixed charges are those prevalent in the city, as are the rates assumed for electric current and heating. The rate of $7 per day for the six elevators is an estimate, as is the 2c. per 100 cu.ft. for pumping. In 1911, the plant paid a dividend of $5227.84 on an initial cost of $30,000. This is a dividend of 17.4 per cent. For 1912, a net earning of $6450.24 raised the percentage to 21.5, figured on the original investment, with no reduction to the depreciated value. To the present value of the plant the earnings would bear a much higher ratio.

To arrive at the cost per unit of generating current is difficult, as the steam for the pumps and engines has not been separated; the same applies to the labor and supplies. An approximation would be to deduct the earnings for other services from the total expenses and divide by the kilowatt-hour output. For 1911, the balance left for the generating plant would be

$$\$11,971.03 - \$9866 = \$2105.03$$

Dividing by the output, 244,429 kw.-hr., gives

$$\$2105.03 \div 244,429 = \$0.0086 = 0.86c. \textit{ per kw.-hr.}$$

For 1912, the balance would be

$$\$12,660.87 - \$9912 = \$2748.87$$

Dividing by the output gives a cost per kilowatt-hour of

$$\$2748.87 \div 306,637 = \$0.00896 = 0.896c.$$

While these figures are only an approximation, they show that the plant is giving good service and that its commercial life is not seriously endangered.

* *

Reconstructing Water-Tube Boiler Settings*

By Osborn Monnett†

SYNOPSIS—With a hand-fired furnace the boiler should be horizontally baffled, and department No. 8 furnace is recommended. Some interesting low-headroom installations.

Cleaning up hand-fired settings in connection with water-tube boilers is comparatively simple if the boilers are of the horizontally baffled type, as ordinarily there is enough headroom for a good hand-fired furnace and the proper combustion-chamber areas. In working over this kind of setting, the No. 8 furnace should be used. (For reference, see page 266 of the Aug. 25 issue.) Vertical baffles in a water-tube boiler must be horizontal before there is any hope of cleaning up the setting.

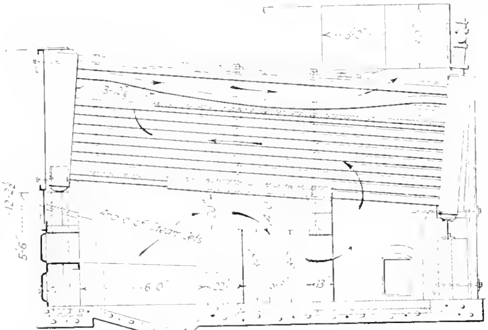


Fig. 1. Drumless Edge Moor Water-Tube Boiler, 215 Hp., and Hand-Fired Furnace

Sometimes an installation must be made under restricted headroom, particularly in office-building plants where the architect usually neglects the boiler-room space until the construction has gone so far that no adequate headroom is available. There are, of course, other circumstances that sometimes govern the doing of low-headroom jobs on new work.

Fig. 1 is a typical installation which, as an afterthought, was made in a modern office building. The original intention was to use central heating service. There was 14 ft. for headroom and the problem was solved by installing a drumless Edge Moor boiler with a combination T and box tile hand-fired furnace, having the deflection arch described in previous articles. The dis-

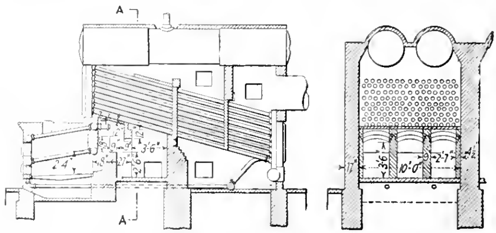


Fig. 2. A 400-Hp. Water-Tube Boiler and Down-Draft Furnace with Sprung Arch to Provide Travel and Mixture

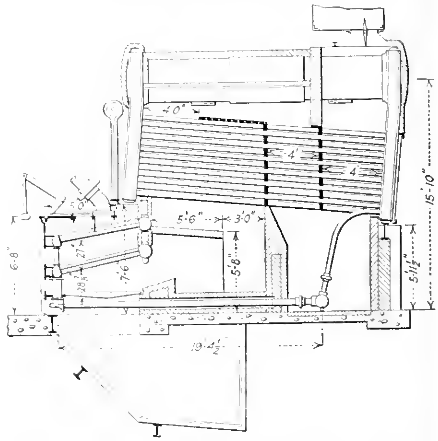


Fig. 3. Babcock & Wilcox Boiler, 300 Hp., with Full Extension Down-Draft Furnace and Mixing Arches

†Smoke inspector, City of Chicago

tance from the floor to the bottom of the front header was 5 ft. 6 in., and from the top of the front header to the floor it was 12 ft. 2½ in. With proper operation this setting can be expected to give good results.

Vertically baffled water-tube boilers are sometimes equipped with down-draft furnaces, both full extension and flush front, but the combination generally makes a bad smoker. The flush front setting must be horizontally baffled before it can be cleaned up. With the full-extension furnace it is possible to interpose brickwork construction which will increase the flame travel and mix the gases before they strike the heating surface.

Fig. 2 illustrates a full-extension, down-draft setting for a water-tube boiler, in which an arch 5 ft. 6 in. long has been sprung back of the bridge-wall, with sufficient throat area past the arch to allow the gases to escape. The bridge-wall action is good, as the radiation from it has the effect of maintaining the temperature of the gases, and as the gases impinge against it in changing their direction, combustion is aided materially. In new down-draft furnaces and water-tube boilers, the latter always should be horizontally baffled and the furnace have deflection arches.

Fig. 3 shows another down-draft installation set full extension. As shown in the drawing, the construction

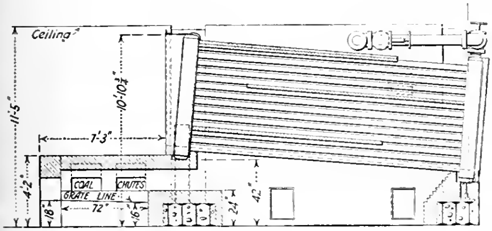


Fig. 4. A 375-Hp. Drumless Edge Moor Boiler and Burke Furnaces Set in Headroom of 11 Ft. 5 In.

calls for a high-temperature zone over the bridge-wall and a deflection arch in three spans before the gases pass to the heating surface. These compromise settings must be taken for what they are worth in cleaning up existing plants rather than as satisfactory settings for new installations.

Fig. 4 illustrates an interesting case where a 375-hp. drumless Edge Moor boiler served by Burke furnaces was set in a headroom of 11 ft. 5 in. Here are conditions which are sometimes met when putting a new power plant in an old building. In this case the building stood on a floating foundation, consisting of a mass of concrete and railroad iron in which it was impossible to do any excavating. At the same time it was impossible to raise the ceiling as it would then interfere with valuable floor space in the office building above. Therefore, the boiler installation had to be sacrificed and the design shown herewith was adopted. One of its features was the location of the safety valves. The headroom was so restricted that they had to be set, one on the side of the header, with a U-tube connection into the steam space of the boiler. Notwithstanding the conditions, these settings have been running successfully for years without smoke and without any unusual difficulty with the boilers.

Waste Hot Water Heats Feed-Water

By F. B. Hays

The writer recently designed a chemical plant in which several novel engineering features were embodied. The most interesting, from a power standpoint, was the manner in which the boiler feed water was heated.

The plant contained a battery of three boilers, two being in service while the third remained idle for clean-

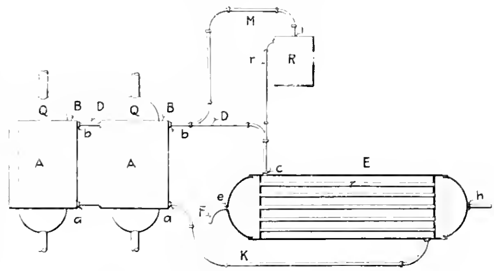


Fig. 1. Jacket of Chemical Tanks as Feedwater Heaters

ing or emergency. The steam was used directly in reduction tanks, becoming a part of the final chemical composition manufactured. This left no exhaust steam for heating feed water, and as there was much waste heat in the plant, it was not considered advisable to use live steam. Cooling water used to reduce the temperature and prevent explosions in the chemical reduction tanks was going to waste. After a careful study of the operating conditions in the reduction tanks it was decided that the cooling water could be used for heating the boiler feed water, and the latter kept at a fairly even temperature provided a suitable heater was installed. The heater shown in Fig. 1 was finally chosen.

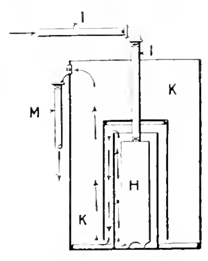


Fig. 2. Section of Overflow Box

The general arrangement of the whole system is shown in Fig. 1, in which are the reduction tanks *A*, where temperatures ranging from 70 to 600 deg. F. are produced by the chemical reactions; the water jackets *B* surround the cookers *Q* of the reduction tanks, into which the cooling water enters at *a*, and, becoming hot, flows out at *b* and through the pipe *D* into the boiler feed-water heater *E* at *c*. The boiler feed water (cold) passes through the pipe *F* and enters the heater at *e*. It leaves the heater at *h* for the boiler-feed pump, after it has become heated by the cooling water from the reduction tanks, and has in turn cooled this cooling water. The cooling water returns to the reduction tanks by the pipe *K*. The circulation of the cooling water is by gravity.

Due to the high temperature frequently produced in the cookers, provision had to be made to take care of steaming of the cooling water. This was done by means of an overflow pipe *M*, which discharged into the radiator *R* at *i*, from which it flowed into the heater *E* at *r*.

The construction of this radiator is shown in Fig. 2, where I is the pipe by which the water and steam from the reduction tanks enter the radiator, H the tubes where the steam is condensed, K the water tank of the radiator, and M the overflow pipe from the water tank to the feed-water heater. The object of this type of radiator was not only to condense and utilize the steam from the cooling system, but also to keep hot water flowing into the feed-water heater at all times. Since the temperature in the cookers varies as much as 400 deg. in an hour, it will be readily seen why such a device is necessary. On account of this same variation in temperature, the cubic contents of the feed-water heater had to be far in excess of that normally used or required in proportion to the area of its heating tubes, so that it would act as a large heat reservoir, which would not be readily affected by sudden changes of temperature of the feed-water passing through the cookers.

Will Quizz, Jr.

SYNOPSIS—Will Quizz asks about the shape of steam nozzles and is surprised to hear that an enlarging nozzle of the correct proportions will cause an increased velocity of the steam jet.

"Chief, what is the reason for the shape of the nozzles in our turbines? Instead of pointing the little end of the nozzle toward the rotor the big end points there."

"This is done, Will, to give a greater velocity to the steam. Fig. 1 shows that the velocity of steam issuing from a straight nozzle is almost constant for all pressures."

"How can an enlarging nozzle increase the velocity?"

"It is like this, Will: back in 1883 Dr. DeLaval made the first use of such a steam turbine by applying it to milk and cream separators. After experimenting, he concluded that the successful motor of this type should utilize the velocity of the steam rather than its direct action by pressure. His first step, therefore, was to convert the force in the steam into kinetic energy and obtain the highest possible velocity for the steam. He conducted a number of experiments and established the shape of the nozzle which would produce this effect.

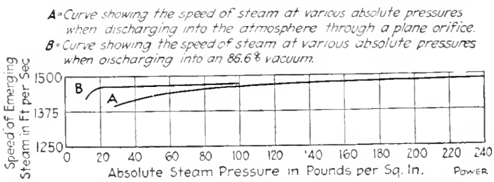


FIG. 1. STEAM VELOCITIES WITH STRAIGHT NOZZLE

"Probably the easiest way to describe this would be by comparing the steam in the boiler under pressure with a lot of toy balloons in a closed vessel under sufficient air pressure, so that each one, instead of being some four inches in diameter under atmospheric pressure, would be compressed to perhaps one inch.

"Suppose then these balloons were allowed to escape through an opening just large enough for one to pass through at a time and into the nozzle of the shape shown. Immediately after passing through the small end they would begin to expand by reason of the reduced external pressure, but if the nozzle did not enlarge in proportion to this expansion it would elongate and increase its velocity as it expanded.

"This elongation necessarily would have to take place in the direction of the flow because the others, following under pressure, would urge it forward and prevent any rearward elongation or even any retarding of the outward flow, so it will be seen that the velocity must increase in order to allow for the expansion. Fig. 2 shows the increasing velocity of the steam issuing from a properly designed diverging nozzle.

"Referring to your steam tables again, Will, you will see that the specific volume of one pound of steam at 465 lb. pressure is one cubic foot. At lower pressures the volume is greater, and at atmospheric pressure one pound occupies about 27 cu.ft. (or 27 times the original volume for a given weight of steam). As the pressure decreases below that of the atmosphere the volume increases rapidly, so that at one pound absolute pressure it occupies 333 cu.ft.

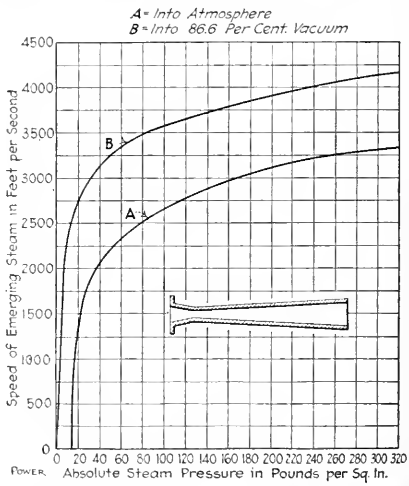


FIG. 2. STEAM VELOCITIES WITH ENLARGING NOZZLE

"The shape of the nozzle—that is, its rate of enlargement—must be proportional to the initial pressure and terminal pressure against which the steam flows, but the more extreme these two pressures are, the more abruptly the nozzle may enlarge. Therefore, nozzles are of different proportions or designs for different boiler pressures and the amount of back pressure or degree of vacuum into which the steam is discharging. With a given area of throat or small section the area of any section beyond is directly proportional to the specific volume and to the dryness of the steam, and inversely proportional to the velocity."

Editorials

Value of the Extra Man

How many manufacturers believe that it would pay to employ an extra man in the engine room, so that the chief engineer would have more time to devote to the boiler room and see that the maximum fuel economy is maintained?

Fuel is the main expense in all power plants, and although many consider it, more ignore it.

In one plant for instance, the owner will not be bothered about the coal, but insists on purchasing the engine and cylinder oil himself. The fuel item would run into thousands of dollars annually; the oil would cost a few hundred.

As pointed out in a first-page cartoon some time ago, the switchboard of most electrical plants carries all the necessary recording and indicating instruments, so that the attendant can keep a record of the output in electrical energy. But out in the boiler room there are only the old safety valve, water glass and pressure gage, with nothing to indicate the performance of the boiler. The bills for coal and supplies come to the office and, although protest may be made against their size, nothing is done to help the engineer reduce them.

In other plants some attempts may have been made to obtain efficient operating results, and perhaps instruments for ascertaining the percentage of CO_2 in the furnace gases have been provided, together with draft gages, steam-flow meters, etc., but if no attention is given them, they might just as well be cut out for all the good they may do.

Pointing out defects is useless, unless measures are taken to remedy them. If help is so limited that there is not time for some one in authority to find the source of loss and to see that matters are changed for the better, then good American dollars are going to waste, because nobody is held responsible for the loss.

Engineers well know the situation, and there are many of them who are striving, even against adverse conditions, to operate their plants economically. There are others who are indifferent, because the men higher up do not do their part in preventing losses.

With so many plant owners and managers lax in this regard, it is refreshing to know that one manufacturing company (see the article, p. 38) realizes the greatest opportunity to save is in the boiler room, and that an overworked engineer cannot give proper attention to securing economical operation. For this reason an extra man is employed in the engine room so that the engineer may give time to getting all possible out of every pound of coal consumed in the boiler furnaces. Moreover, instruments are provided to show the operating conditions, and are so arranged that any one of the boilers can be checked by the instruments.

How many power plant owners believe that if the chief engineer is given the opportunity he can more than save a man's wages by properly managing the boiler room? Why not give him a chance and find out?

Getting New Business

Small electric-light plants may note with profit the accomplishment of the Springfield (Missouri) Gas & Electric Co., which has added two hundred new residence customers to its circuits in sixty days, with no line or transformer expense.

This increase in new business is largely accounted for by the fact that the company offered to put in a few outlets, and did not insist on wiring the houses complete before putting in the service. This naturally appealed not only to owners, but to renters of even small houses. With the service once in, the convenience was apparent, and additional outlets were added here and there, so that what did not represent an attractive connected load at first has gradually become a profitable one.

A small station cannot hope to obtain the same number of new connected houses in the same period as did the Springfield company, but what is to prevent the idea from being worked out on a smaller scale in smaller cities and towns? It would appear to be worth trying.

Water-Power Legislation

Hearings on the Ferris water-power bill, before the Senate Committee on Public Lands, developed that its passage in the Senate will be opposed on two grounds. A small clique of Western senators will oppose the measure because they want the dam sites in the public domain deeded over to the states without condition. The influence of large hydroelectric promoters and operators will be exerted against it because they want power sites given to the companies in perpetuity. The bill as it passed the House proposes that power sites on the government lands shall be leased for not more than fifty years, and that the property shall revert to the government at the end of that period.

It was brought out at the hearings that Canada, Norway, Sweden and other countries where there are large water powers have secured their development under very much the same plan as that now urged by the administration and embodied in the Ferris bill.

Upon the action of the Senate on this bill and on the Adamson dam bill, both of which have passed the House and are awaiting senatorial action, depends whether there shall be any extensive development of water powers in the United States in the near future. Under present laws, such development is almost impossible. So far as Western water powers are concerned, they are practically all in one of two classes: either held in private ownership by large corporations which form what Gifford Pinchot and others declare to be a "water-power trust," or they are within the public domain, under the ownership and control of the Federal government. In the East and South, there are also large potential water powers on navigable streams which can be utilized only by permission of Congress.

The War Department claims jurisdiction over navigable streams, on the ground that any obstruction of these affects navigation, which is under Federal control. In the public domain, there has been some granting of permits for water-power development along streams in forest reserves, which are under the control of the Department of Agriculture. So far as power sites in the public domain outside of the forest reserves are concerned, however, there is no law permitting any leasing or permits. They must either be withheld entirely from use, or given away as farm lands to anybody who asks for them. Judge Finney, of the Interior Department, told at the hearings of one power site acquired by a power company from the government at one dollar and twenty-five cents an acre as agricultural land, and capitalized at twenty-six million dollars by the corporation which secured it.

These water-power hearings have brought out clearly the story of how the water powers of the West are monopolized, and the ramifications of the big power corporations. They have also served to point out forcibly the difficulty that exists in drawing the line between state and Federal authority in the control and regulation of these matters. All the water in the streams is owned by the states. The courts have said that more or less clearly. So far as its use is concerned, however, the Federal government has control over everything affecting navigation, and the courts have not decided just how far back toward the source of the stream that extends.

In the proposed general dam bill, the power claimed by Congress is drawn entirely from its right to control navigation. Even if a corporation owns a dam site, and the state in which the site is located has granted a right to the use of the waters of the stream, the dam-site owner cannot build his dam without the consent of the Federal government, on the theory that the dam might interfere with navigation. In the past, permission for the building of dams and power plants along such streams has been made the subject of special acts of Congress, it being necessary for a company to get a specific act through Congress to enable any dam to be built. In the pending bill, it is proposed to make a general law governing the granting of such permission, and allow the Secretary of War and the Secretary of the Interior, under certain restrictions and conditions, to grant such permits.

The Adamson bill would open to use, under regulation, the unused water powers and power sites in the East, South and Middle West. The Ferris bill deals with the water powers in the public domain, which is almost wholly in the far West. The latter, in fact, makes no proposal for regulating the use of water powers, but deals wholly with power sites. However much power there may be in a stream or a waterfall, it is useless unless there is a place to build a plant for its development. Where these dam sites and power-plant sites are on land owned by the government, the Ferris bill proposes that the government shall lease the sites on such terms as will enable the government to forever control the development of power at that point.

In an effort to propitiate the "states' righters," the Ferris bill proposes that where electricity is used in the same state in which it is generated under a Federal lease, the operations, rates, etc., shall be subject to state regulation, where there is a state utility commission. Where there is no state regulation, the government is to do the regulating. Where power is generated in one state and carried into another state for use, that used in the state where it is generated is to be under state regulation and that in the other state to be under Federal regulation. Where the company does an interstate business, however, not only the current which is sent across the state line, but also the entire assets and affairs of the company generating the power will come under Federal control and regulation. In actual operation, it seems probable that the effect of the proposition, if the bill becomes a law, will be to have both Federal and state regulation over the same enterprises.

The bill proposes that the rental charged by the government for the power site shall be decreased in proportion as the operating company decreases the price to consumers for light and power. Senator Smoot, of Utah, who opposes the measure, ridiculed this proposal in the committee hearings, on the ground that it would be more profitable to the companies to pay the higher taxes and exact the higher rates.

The money derived from leases of power sites is to be placed in the reclamation fund, and after it has once been used for reclamation projects and repaid to the government by the water-users on these projects, it is then to be equally divided between the states and the government.

Encouragement

How many chief engineers encourage their men by expressing satisfaction when work has been well done? How many comment favorably upon the personal appearance of their assistants? What would be the result if appreciation were expressed? Nothing will encourage a man to do his best so much as the knowledge that his work has received recognition. Nothing will cause a man to become disgruntled so much as an attitude of nonappreciation on the part of the chief.

An assistant engineer need not fear being classed as a "dude" because he prefers to go about his work with clean clothes. If he does not keep himself clean and neat, the chances are that he will be slovenly about his work. Some engineers have the appearance of coal passers, and their plant presents the appearance of having seen better days. No self-respecting man can be content to work in a dirty engine room where it is impossible to keep himself in a half-way presentable appearance. Encourage men to do better work, to keep the plant clean, and their own improved appearance will follow.

If a man thinks well of himself, and he will in cleanly surroundings, he will think well of his chief and of the company that employs him.

Not a single passenger out of the 188,411,876 carried in 1914 on all of the 26,198 miles of track of the entire Pennsylvania R.R. system was killed in a train accident.

This looks to us like real forethought and true business acumen on the part of the Pennsylvania R.R. It realizes that the more passengers it kills the less it will have to carry, so it tries not to kill any. Last year it was successful and had a perfect score—no misses.

Indexes to Power are furnished free to all who request them. That for the last half of 1914 will soon be ready. A simple request, addressed to the Subscription Department, Power, will bring one.

Correspondence

Stresses in Convex Heads

In the Dec. 8 issue there is a discussion of my contribution to the issue of July 7 concerning stresses in convex heads. The first remark by Mr. Vander Eb to the effect that the results of my analysis are at variance with opinions previously expressed depends on the point of view. When an abstract analysis of a statical or physical problem is undertaken, all opinions, even those of the mathematician, are irrelevant. The matters pertinent to the analysis consist of, first, the premises upon which the analysis is based; second, the propriety of the mathematical processes that are employed, and, third, the specification of the consequences of the analysis. I fail to see anything peculiar in the fact that an attempted analysis of a problem in statics leads to results at variance with current opinion since current opinion, heretofore, has been at variance with the facts concerning the safety of convex heads.

Concerning the more direct discussion of the analysis by Mr. Vander Eb it is fair to examine the premises upon which my analysis is based for the errors which are said to exist. He asserts that I have neglected the deflection of the dished part of the head "by simply assuming that a purely spherical tension at the circumference is all one need to expect." If anything new in the way of theory of stress in spherical shells, or in portions of them, can be offered, there may be sufficient evidence to enforce the abandonment of the respect for such writers as Rankine, Church, Merriman and Cotterill.

There is nothing more explicit than the statement of Rankine ("Applied Mechanics," p. 290), viz., "hence the whole force to be resisted by the tenacity of the shell is," etc. The statement admits of no shearing stresses or any stress in the spherical shell other than a simple tensile stress. The presence of shearing stresses would cause local deflection from the spherical surface and their absence precludes "deflection."

Referring to Fig. 2, by Mr. Vander Eb (which is substantially the same as Fig. 4 of the July publication), it will be seen that the element of the flange fillet is completely supported by the system of forces as specified. Some of these forces constitute "reactions" on the part of adjoining material which, if properly accounted for, dispose of further consideration of such extraneous material in the analysis. I have shown the justification for the acceptance of the force T as a simple tension unaccompanied by shear stresses on the face DC of the element. If there is any bending of the material of the plate at the section AB, there is at least a "stress couple" and possibly shearing stresses. By the selection of the origin of reference at O', at the middle of the plane AB, all effects of these shearing forces from the moment equations are eliminated.

A little reflection and reconsideration of the detailed analysis in the article of July 7 will show that Mr. Vander Eb is wrong in asserting that the element of the flange fillet is considered as a beam with "free" ends. The remainder of this paragraph in the Dec. 8 article is somewhat questionable in the attempted substitution of impressions, however plausible they may appear, for the logic and conclusions of a statical moment equation that is either right or wrong. In the interest of engineering progress, the elimination of errors should be the ambition of all concerned. I cannot see the justification for the introduction of the forces on the sides of the element (Fig. 3 of the July 7 article) for reasons explained originally.

Mr. Vander Eb overlooks the fact that the analysis contemplates attachment of the convex head to a rigid cylindrical shell as "a yield of the structure at the flange connections would seriously complicate the stress-strain relations." Furthermore, a yield at this point would be incapable of analysis with the present limitation of the theory of statically indeterminate structures.

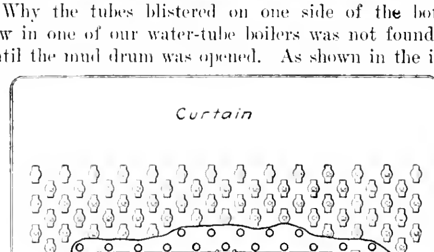
With much of the remaining discussion I have but little reason to dissent. One criticism of my article, and all similar articles, was overlooked which I will undertake to supply. The analysis may be wrong because it has assumed a homogeneous molecular state of the material in the plate after it has been heated, flanged, cooled and forced into shape and place by any practicable flanging process. There is no means of estimating the magnitude of the initial strains in a dished head, and particularly in the region of the flange fillet. These may be, and in certain cases actually have been, so severe that the heads cracked while they were being riveted to the shell. At the risk of a small increase in cost of boiler construction, a flanged head could be subjected to suitable heat treatment or at least proper annealing when, if ever, the plate may be assumed to be free from internal strain.

F. G. Gasche.

South Chicago, Ill.

Side Tubes Blistered

Why the tubes blistered on one side of the bottom row in one of our water-tube boilers was not found out until the mud drum was opened. As shown in the illustration, the blowoff was connected to a tee inside of the mud drum, into which were screwed two short lengths of pipe supported about 2 in. from the bottom of the drum and having ½-in. holes drilled in the lower sides and the ends capped.



Blowoff Pipe Open at One End

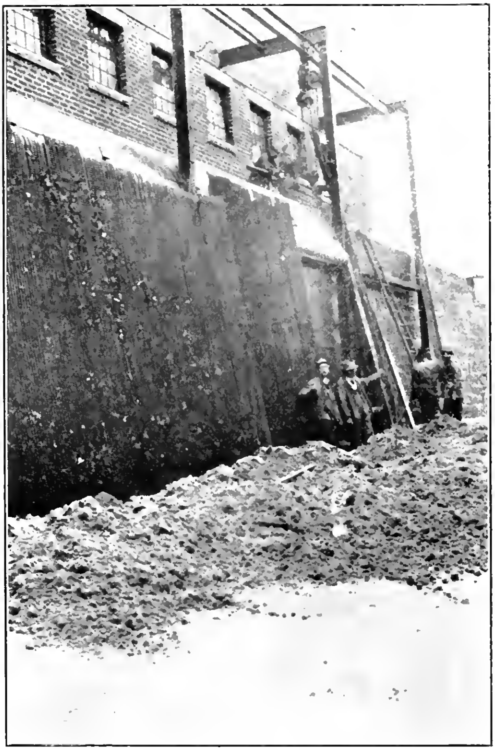
One of the caps had worked off and consequently all of the drainage or blow was from that end. The sediment gradually accumulating at the other end had stopped the circulation in the tubes and allowed them to become overheated.

EDWARD T. BINNS.

Philadelphia, Penn.

High-Pressure Water for Cleaning

New trash racks were to be placed in front of the water-wheel chambers at the hydro-electric plant in which the writer is stationed. On letting the water out of the head



DIRT AT THE INTAKE SCREENS

race, which is about 16 ft. to the concrete footing on which the bottom of the racks were to rest, the footing was found to be covered with sand to a depth of 4 or 5 ft. Much of this sand was removed by shoveling, but as there was some water dammed up behind this bank, which could be drained out, the sand was washed in almost as fast as it could be shoveled away.

In the plant we have mains carrying water at a pressure of about seventy pounds. The use of this water to do the work was suggested, and the plan was carried out with success. A line of 3-in. pipe was coupled to the water main, and to this pipe a 3-in. suction hose was connected. A nozzle was needed and as none was at hand, we proceeded to make one out of a short piece of 3-in. pipe about 3 ft. long and threaded at one end. The other end was heated in a forge and the edges flattened, leaving an outlet 1½ in. diameter and flared back to the diameter of the pipe. This nozzle was coupled to the hose and the full pressure turned on. The sand was thoroughly stirred and in a short while most of it was carried off. The rest was kept constantly stirred by the water, and the racks, section by section, quickly dropped into place. The illustration shows the head race.

J. M. PURCELL.

Richmond, Va.

Starting Small Motor

We have a small direct-current, shunt-wound motor that had been used satisfactorily for driving a bottle-washer by throwing directly across the line in starting. When it was belted to a jig-saw, where there was more friction, it had to be helped in starting. Believing that the heavy starting current might have so weakened the shunt field as to reduce the torque, the writer placed a bank of lamps in series with the armature, upon which the motor started easily, although the running speed was reduced somewhat.

It appears that above a certain point an excessive armature current in a shunt motor reduces the torque instead of increasing it.

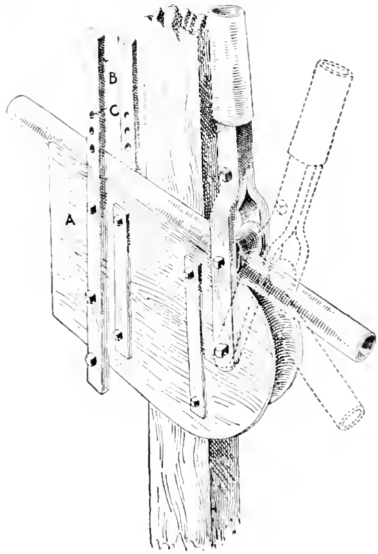
WALTER S. GRISCOM.

Buck Hill Falls, Penn.

Pipe Bender

In a plant where it was necessary to bend pipe of various sizes from 1 to 2½ in., the simple pipe bender shown did good work.

A 2-in. hardwood plank 18 in. long by 12 in. wide,



PIPE BENDING FORM CLAMPED ON POST

rounded off at one end to a 6-in. radius, was fastened to a post in the shop. Two pieces of 1½x½-in. flat steel *B*, one on each side, and extending 5 in. above the top of *A*, had a number of ¾-in. holes for a pin to hold the various sizes of pipe. On the rounded end was fastened a swinging arm or lever and roller held in place by a bolt through two pieces of 1½x½-in. flat steel, and pipe extensions of different lengths furnished the required leverage to bend the various sizes of pipe.

The method of operating is to hold one end of the pipe to be bent in the space between *A* and a pin in *C*, and bring the roller to bear slightly, then draw the pipe forward an inch or two and repeat the operation until the required bend to any number of degrees is completed. This apparatus is inexpensive, easy to construct and is convenient for making offsets and lateral bends.

W. E. CHANDLER.

Quinebaug, Conn.

Gaskets for Plugs of Compressor Valves

In the Nov. 10 issue, Mr. Herr asks for information about material for gaskets for plugs in ammonia-valve bonnets.

There are four kinds of valve bonnets for ammonia compressors. The most common form is such as is found on the Linde type of machine. It is held in place by studs or capscrews and the gasket fits into a recess so formed that the male part of the bonnet holds the valve cage down to its seat in the casting. Almost any ordinary gasket, rubber, lead or other material, will make a tight and lasting joint. One-sixteenth-inch lead or rubber sheet packing is much used, but if the joint is troublesome the use of one-sixteenth-inch rubber packing of nearly pure gum is advisable.

Before inserting the gasket, it should be noticed that the top of the valve cage projects about one-sixty-fourth of an inch beyond the surrounding surface. If the cage has been ground into the seat and the top is below this surface, an extra gasket must be used which fits the valve cage only and acts as an extension to it, allowing the bonnet to hold the cage tightly in place. Neglect of this will allow leakage between the head or cylinder casting and the cage, proving no better than a leaking valve. This style of bonnet is found on compressors of many makers.

There is a bonnet where the valve cage is set in the compressor head and held to its seat by a ring or nut; the bonnet is screwed into the head outside the ring. Rubber gaskets are supplied by the builders of the machine and never give any trouble when inserted properly.

Then we have the style of bonnets used on the old Boyle and Pennsylvania Iron Works compressors. Here a yoke is used, the studs being screwed into the compressor head and an iron strap reaching from one stud to the other, with the valve bonnet between the two studs. A setscrew passes through the strap and when screwed down forces the bonnet to its seat. The same material can be used for gaskets as in the Linde type, but pure gum is preferable as it is soft and does not require such pressure as does lead to make a tight joint.

There is another type where the valve cages are put in from the cylinder side of the compressor head and the bonnet screws onto the threads on the outside of the upper end of the valve cage. The cage is kept from turning by a dowel pin. Sheet lead one-sixteenth-inch thick is the proper thing for these gaskets as the turning effect of the bonnet might tear or misplace a rubber one. If the joint is a particularly troublesome one, put a gasket of one-thirty-second-inch pure gum beneath the lead. There is no reason then why the joint should not be tight unless there is some defect in the casting or the valve cage is too long, the top of it striking the inside of the bonnet before the gasket is pressed tight.

The temperature of an ammonia compressor should never be so high that it will melt lead. Use plenty of water over the jacket or send the suction vapor to the compressor in a slightly saturated condition. Properly cut and inserted gaskets of either one-sixteenth-inch sheet lead or of good sheet rubber will keep these from leaking unless something is mechanically wrong.

The nuts, capscrews or screwed bonnets of compressor valves must be frequently tried with a wrench as the changes of temperature to which they are subjected will cause them to become loose.

A. G. SOLOMON.

Chicago, Ill

Cylinder-Head Packing

A good gasket, which will hold where rubber will not, may be made of copper wire if the surfaces are reasonably smooth and true. The copper should be annealed by heating it red hot, then dipping it into water once or twice, or until soft enough. Gaskets may be made of any size suitable to the work from ⅛ in. to $^1/_{64}$ in. After the wire has been annealed, draw it around the cylinder head and twist it a couple of times, and then flatten the twist a little thinner than the wire.

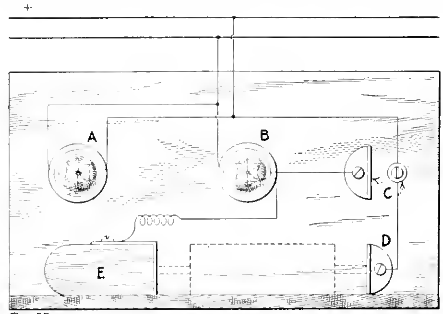
Either solder the ends or wind candle wicking around the joint. Put the cylinder head on and draw up evenly on all the bolts, and then hammer a little on the head over the wire to flatten it. Next, take up snugly on the bolts. Soldering the gasket to the head will keep it in one position all the time and will be convenient if the head is to be removed frequently.

JOHN P. KOLAR.

Ithaca, N. Y.

Lamp and Fuse Tester

I have a simple and convenient tester for lamps and fuses, the wiring plan of which is shown in the illustration. The metal part of the socket *A* is slit and opened



LAMP- AND FUSE-TESTING BOARD

so that the lamp need not be screwed in, but simply pressed in.

B is a lamp screwed in permanently as an indicator in testing plug fuses at *C* by placing the end on the bottom connection and the side in contact with the metal side. If the fuse is good the lamp at *B* will light up.

Contacts *D* and *E* are for testing cartridge fuses. The dotted line shows a fuse in place with the sliding, metal-bound block *E* pressed against one end. The outfit can be mounted on a marble slab or asbestos-covered board to suit one's fancy.

James G. Sheridan.

Brooklyn, N. Y.

Pottery Clay in Fireclay Service

In the Dec. 15 issue of Power appeared an article on the use of cement for furnace lining as practiced by the Robert Gair Co., Brooklyn, N. Y. This called to mind an experience I once had in repairing the setting of a 250-hp. water-tube boiler in a remote part of the West Indies.

One day we found ourselves short of fireclay, due to a delay in shipment, and it was necessary to repair the boiler setting at once, and replace practically all the firebrick around the door arches, etc. We tried to buy or borrow enough fireclay to do the work but everyone seemed to be short at the same time.

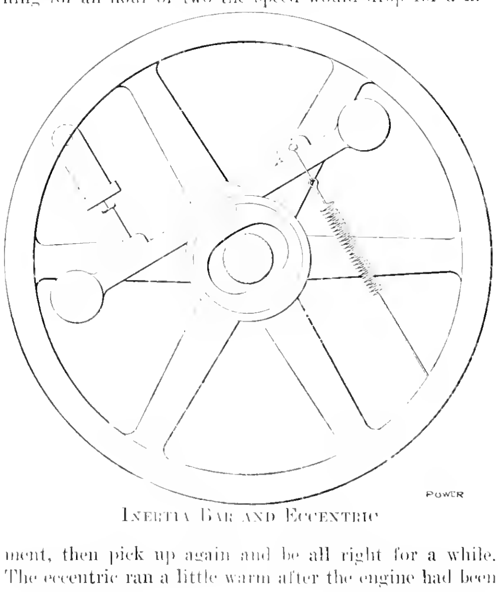
In the neighborhood was a small pottery plant, so as a last resort we decided to see how good a fireclay this unburned pottery clay would make. We were surprised to find that it lasted longer than the brick and fireclay around it.

F. E. Wood.

Whitinsville, Mass.

Trouble with Inertia Governor

An inertia governor of the type shown gave considerable trouble on account of its sluggish action. After running for an hour or two the speed would drop for a moment, then pick up again and be all right for a while. The eccentric ran a little warm after the engine had been off for repairs and the eccentric straps were tightened up. The added friction, however, retarded the governor, causing earlier cutoff and reduced speed. When a paper liner was put in the trouble stopped.



Inertia Bar and Eccentric

At another time the same engine ran unsteadily. Changing the adjusting screw in the oil bypass of the dashpot helped some, and when a lighter grade of oil was substituted, the engine governed satisfactorily.

Sometimes the roller bearing, which has $\frac{5}{32}$-in. rollers, wears slots in both the bushing and the pin. This retards the action of the governor, but a new set of rollers, a pin and bushing will make it entirely new.

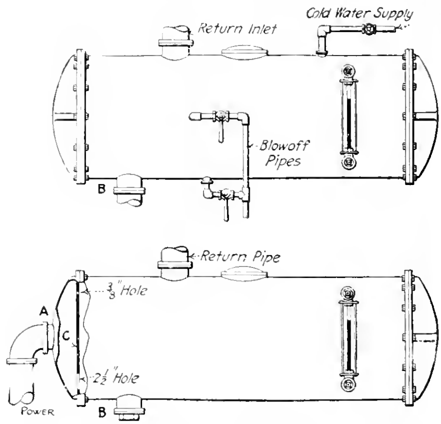
Governors of this type must work very freely, otherwise they cause a great deal of trouble.

J. C. Hawkins.

Hyattsville, Md.

Oil from Heater Got into Boiler

The top diagram shows a combined feed-water heater. In our plant the returns from the heating system and the exhaust from other pumps and engines return to this heater. There is no oil separator in the exhaust line from the pump, consequently oil gets into the heater.



Heater before and after Being Remodeled

As originally installed, the apparatus gave no trouble so long as the man in charge was careful to use the blowoff cocks to rid the heater of oil. One night the fireman pumped the heater dry, not noticing the lowering water level until too late. There was considerable oil in the heater at the time and it got into the boiler.

To avoid further trouble, the suction line to the heater was made to enter the tank in the center of the head as shown at *A*, while the original suction line *B* at the bottom was plugged. Between the head and shell there was placed a sheet-iron plate *C*, $\frac{1}{8}$ in. thick. At the top a $\frac{3}{8}$-in. hole was bored and at the bottom a $2\frac{1}{2}$-in. opening was allowed in the plate, the water going out of this hole on its way to the pump. The function of the $\frac{3}{8}$-in. hole is to prevent the pump from siphoning the water in the heater over into the suction line. With this arrangement we are never troubled by oil getting into the boiler.

H. G. Gibson.

Washington, D. C.

Former Engineer of La Salle Hotel Defends His Administration

The attention of readers of POWER is called to the article appearing in the Nov. 3 issue of that paper, page 628, in which statements were made that the power plant in the Hotel La Salle, Chicago, Ill., was not operated efficiently during the years 1910 and 1911. The following facts and figures are in contradiction to these statements.

The Hotel La Salle was opened in 1909 under strike conditions of the mechanical trades, there being thousands of dollars' worth of unfinished work which had to be finished after the house was opened. Also revision of plans and certain changes necessary to be made to suit conditions made an enormous amount of extra work to be completed by the engineering department and necessarily created a large expense for labor and material, which was chargeable to the engineering department, but should not have been charged as an item of operation.

It was required by the management at that time that the house be thoroughly ventilated at all times, which required all ventilating fans to be operated constantly at their scheduled speed for furnishing the quantities of air required. Voluntary information handed the writer from a person who served in the mechanical department under Mr. Bird, present chief engineer, states that replacing the 16-cp., 60-watt lamps through the house with 25-watt tungstens shows a saving of 43? kw. on lighting load alone. This change was often suggested by the former engineer, but was not entertained by the management. He also states that over 100 hp. in motors were closed down, the greater part being on ventilation. Relative to these items, it is beyond contradiction that there is any credit or discredit due either engineer, as the same saving would have been effected had the company seen fit to make such changes in service before.

It is not the purpose of this article to reflect on the present management of the plant, but simply to submit to your readers such facts and figures as will contradict the misleading statements reflecting on the former management.

The steam traps mentioned in the article of Nov. 3 were one of the best known makes, which gave excellent satisfaction, and owing to the complete system of piping there were but very few traps required for the handling of all condensation from the entire house, each trap being fitted with test valves below the valve in the main discharge pipe in order to test the traps for leakage. Each trap was tested daily by closing off the discharge valve and opening the test valve, allowing the trap to discharge into the atmosphere, to determine if the trap was working properly, it seldom being necessary to renew seats or valves. It is therefore flatly contradicted that there was any loss of steam from this source.

Also during the time the hotel plant was operated by the chief engineer previous to Mr. Bird's time, vacuum cleaners were in constant use. They were three in number, and a great deal of the time during the day the three were in use at once. Probably POWER has not been informed that these are now used but very little.

Another item which should have reduced the operating expenses of the plant was the discontinuing of several hundred lights around the banquet-hall windows and 19th floor. During the previous engineer's time at the La Salle Hotel, these lights were required to burn from lighting time in the evening until 1 a.m. It can readily be seen that by discontinuing these lights the load would be greatly reduced, which also has no reflection upon the engineer.

There were always constant changes being made in rooms, kitchens and other portions of the house for the first two years which required an extra force of men, all of which came under the chief engineer's charge and were chargeable to his department, although not an item of plant operation.

We wish to state further that during the coal shortage in the winter of 1910, the hotel company, not being under contract with any coal concern, made it necessary to burn whatever coal was on the market, and the greater part of the time coal was used that ran 20 per cent. ash, making it necessary to run from one to two boilers more than should have been run if good coal could have been obtained, to say nothing of the high prices they were compelled to pay. No steam was allowed to go to waste at any time, as a daily record was kept of the amount of water evaporated and the coal burned. These records were absolutely correct, as the meter was inspected once each month by an expert from the Worthington Meter Co., and if any repairs were found necessary, they were made by him. Evaporation was kept up to the highest possible point at all times as the test made by a prominent engineering company of Chicago will show.

In reference to the operation of the different electrical units, it was found to be impossible to change their schedule at that time as the official test also shows they were operated at their most economical point. No steam ever escaped from exhaust pipes in winter except in very mild weather or perhaps for a short interval at lighting time in the evening, while engines were being changed. All rooms were supplied with artificially cooled air in the summer months that were designated to receive it.

The cutting off of this service would also reduce the operating cost, but with no credit to the present engineer or discredit to the former, as the entire plant might be shut down and have no expense at all. It is a well known fact that during the former chief engineer's time at the hotel, the power plant was a credit to a house of its kind. It was light, clean, well kept and with smooth running machinery. Today it will speak for itself. It is a very easy matter to cut down expense at the sacrifice of the plant.

Such furnace changes as were made speak for nothing unless a higher CO_2 or a higher evaporation can be obtained, which the previous article has failed to show, but which is shown by the test made by the engineering company to be above the average evaporation for the best equipped plants. It is plain to see, according to the article printed in POWER of Nov. 3, that no tests of any kind were made by Mr. Bird to determine the amount of work done. The article merely states that "eight pounds of water were evaporated per pound of coal," but for all the figures shown it might be four or it might be fifteen, but not so in this article, as the facts and figures are here in detail and are signed by a company recognized as high authority on scientific tests. Note the evaporation, also cost of generating current, and then compare with the article printed on pages 629 and 630 in POWER, Nov. 3 issue.

It is also a fact that the man who operated the hotel plant previous to Mr. Bird is a person holding a very responsible position with a large and well established firm, he having charge of several large plants, all of which generate their own power and are equipped with high-class machinery, which plants employ a very large force of engineers and mechanics.

No mention was made in the Nov. 3 issue of POWER of the new elevator pump being installed in the La Salle Hotel since Mr. Bird's time, which cost several thousand dollars and from an engineer's standpoint being wholly unnecessary, as the original pumps never failed to handle the nine hydraulic cars all in service at once at high speed, with always one pump in reserve, and at no time were any of the cars shut down except for repairs and then only after 12 o'clock midnight as it required the six passenger cars to handle the enormous number of guests in the hotel at that time. Also the installation of a new hot-water heater, from the same point of view, would be considered unnecessary, as the heater originally installed never failed to furnish sufficient quantities of hot water when the house was filled to its capacity.

Following are some of the important and interesting facts of the tests made by the aforesaid engineering company, a copy of which was given the writer by the hotel management at that time:

Relative to purchasing electrical power: If a lower rate than 1.2c. per kw.-hr. can be obtained from parties selling power, it is recommended electrical energy be purchased during the summer period, viz., May 1 to Oct. 31. The requirements for these six months are approximately 1,540,000 kw.-hr. The average cost to generate 1 kw.-hr. operating as at present is 0.72c. during winter season, 2.2c. during summer season and 1.46c. average for the year.

TOTAL OPERATING COST FOR LIGHT AND POWER

	Winter Period	Summer Period	Total for Year
Proportional operating cost generating steam	$8,152.95	$30,742.75	$39,195.70
Engines and generators, maintenance, material and supplies	527.86	464.11	991.97
Interest on capital invested in engines, generators, switchboard and intermediate wiring ($49,400 @ 6%)	1,482.00	1,482.00	2,964.00
Insurance and taxes on above apparatus ($49,400 @ 2%)	294.00	294.00	588.00
Depreciation on above apparatus ($49,400 @ 1%)	988.00	988.00	1,976.00
Total	$11,741.81	$33,970.86	$45,715.67
Kilowatts generated	1,640,150	1,540,700	3,180,850
Average cost to generate 1 kw.	$0.0072	$0.022	$0.0145

The average cost to generate 1 kw.-hr. of 0.72c. during winter period cannot be expected to improve very much, but it is reasonable to believe that the summer rate of 2.2c. can be reduced. In view of the fact that electrical power generating apparatus is installed and in operating condition, thereby having a fixed charge, also that a permanent engineering organization has been established with its accompanying fixed charges, it will be necessary to obtain a lower rate from parties selling power than 2.2c. per kw.-hr., the present unit cost during summer period. In order to ascertain the actual saving made and the maximum rate that could be paid if electrical power was purchased, the following tabulation was made:

FOR SUMMER PERIOD, SIX MONTHS

	Amount
Coal, 7500 tons, minus 2375 tons*, @ $2.90	$14,862.50
Labor, 3 oilers @ $60 per month	1,080.00
Ash removed, 475 cars @ $2	950.00
Maintenance, material and supplies (from the first table)	464.11
Water, boiler make-up	150.00
Less depreciation on apparatus:	
One boiler and accessories, $13,600, @ 2%	272.00
Engines and accessories, $49,400, @ 1½%	741.00
	$18,519.61
Per kilowatt-hour	1.20

* Coal required for generating live steam necessary to help out exhaust steam demand.

This indicates that a lower rate than 1.2c. per kw.-hr. will have to be obtained in order to make any saving.

General conditions of plant: The power plant as a whole is in good operative condition and shows careful attention on the part of engineers in general upkeep and maintenance of machinery. Indicator cards off engines show good judgment has been exercised in setting valves, adapting them to best suit services that they perform.

Load Factors:	
Total estimated number of lamps (56-watt) in house	22,500
Load factor, per cent.	16
Total connected horsepower motors on 220 volts	431.85
Load factor, per cent	50½

Boiler evaporation test: The data and results of boiler-plant evaporative test are given in addenda herewith. The results are in accordance with good practice obtained from boilers of the type installed and quality of coal fired:

ENGINEERING DATA FOR YEAR ENDING FEBRUARY 28, 1911

1910	March	April	May	June	July
Coal consumed under boiler in tons	2190.2	1888	1880	1770	1769
Pounds water evaporated per pound coal	$5\frac{1}{4}$	$5\frac{2}{3}$	$6\frac{3}{4}$	$6\frac{1}{3}$	$6\frac{1}{4}$
Boiler horsepower generated	727,142	663,678	753,181	654,543	667,857
Lights, kilowatt consumption	156,830	108,160	146,742	142,510	110,000
Power, kilowatt consumption	116,000	110,000	97,828	110,500	108,910
Tons of ice made	193	208	234	249	248
Number cars ashes removed, Illinois Tunnel Co. cars	227	203	176	200	204

1910	August	September	October	November	December
Coal consumed under boiler in tons	2068	2023	1779.8	1718.2	2032
Pounds water evaporated per pound coal	$5\frac{3}{4}$	$6\frac{3}{4}$	$8\frac{1}{8}$	$7\frac{1}{2}$	$6\frac{9}{20}$
Boiler horsepower generated	746,708	833,213	947,876	786,587	806,580
Lights, kilowatt consumption	165,970	184,266	110,065	156,120	128,570
Power, kilowatt consumption	141,000	122,844	100,065	123,560	120,000
Tons of ice made	254	246	248	213	226
Number cars ashes removed, Illinois Tunnel Co. cars	229	223	131	101	150

1911	January	February	Total for Year
Coal consumed under boiler in tons	2084.5	1623.1	22,825.8
Pounds water evaporated per pound coal	$6\frac{3}{10}$	$8\frac{3}{4}$	Av. 6.8
Boiler horse power generated	860,454	865,691	9,313,510
Lights, kilowatt consumption	190,455	160,000	1,759,688
Power, kilowatt consumption	130,455	140,000	1,421,162
Tons of ice made	226	211	2,756
Number cars ashes removed, Illinois Tunnel Co. cars	168	121	2,133

OPERATING COST FOR GENERATING STEAM ONLY

For year ending February 28, 1911

Includes cost labor and material

	Cost for Winter Period	Cost for Summer Period	Total for Year
Boilers	$876.66	$1,231.15	$2,107.81
Pumps	437.91	468.92	906.83
Engine and boiler room	7,932.20	8,287.80	16,220.00
Ash removed	1,983.00	2,369.70	4,352.70
Coal	33,976.40	34,812.28	68,788.68
Water*	240.00	260.00	500.00
Insurance and taxes on steam generating apparatus and portion of building used by power plant ($236,200 @ 2%)	2,362.00	2,362.00	4,724.00
Interest on capital invested in steam generating apparatus and portion of building used by power plant ($236,200 @ 6%)	7,086.00	7,086.00	14,172.00
Depreciation on steam generating machinery ($104,000 @ 4%)	2,080.00	2,080.00	4,160.00
Depreciation of portion of building occupied by power plant ($132,200 @ 2%)	1,322.00	1,322.00	2,644.00
Total	$58,296.17	$60,279.85	$118,576.02

* Boiler make-up water only.

DATA AND RESULTS OF BOILER PLANT—EVAPORATIVE TEST

Total number boilers in battery, 5 at 400-hp. capacity.
Number boilers used in test, 3
Kind of fuel, Illinois coal, Carterville district, No. 3 washed nut.
Kind of furnace, combination water and fire-tube boilers manufactured by Lyons Bros., Depere, Wis.
Grate surface, 3x60 = 180 ft.; 3 x 2600 = 10,800 sq.ft.

TOTAL QUANTITIES

Date of trial	June 28, 1911
Duration of trial	22 hours
Weight of coal as fired	105,078 lb.
Percentage of moisture in coal	5.3%
Total weight of dry coal consumed	99,508 lb.
Total ash and refuse	10,800 lb.
Percentage of ash and refuse in dry coal	10.5
Total weight of water fed to the boiler	718,437 lb.
Water actually evaporated, corrected for moisture in steam	715,204
Factor of evaporation	1.0486
Equivalent water evaporated into dry steam from and at 212 deg. F.	749,962 lb.

Hourly Quantities	
Dry coal consumed per hour	4523
Dry coal per square foot of grate surface per hour	25.13
Water evaporated per hour corrected for quality of steam	32,509
Equivalent evaporation per hour from and at 212 deg	34,089
Equivalent evaporation per hour from and at 212 deg per square foot of water-heating surface	3.156
Average Pressures, Temperatures, Etc.	
Steam pressure by gage	150 lb. per sq in.
Temperature of feed-water entering boiler	212 deg
Temperature of escaping gases from boiler	609 deg
Force of draft between damper and boiler	1.14 in water
Percentage of moisture in steam	0.45
Horsepower	
Horsepower developed	988
Builders' rated horsepower	1200
Percentage of builders' rated horsepower	82.3
Economic Results	
Water apparently evaporated under actual conditions per pound of coal as fired	6.83
Equivalent evaporation from and at 212 deg. per pound of coal as fired	7.13
Equivalent evaporation from and at 212 deg. per pound of dry coal	7.54
Equivalent evaporation from and at 212 deg. per pound of combustible	8.45
Cost of Evaporation	
Cost of coal per ton of 2000 lb. delivered in boiler-room	$2.90
Cost of coal required for evaporating 34½ lb. of water from and at 212 deg equivalent to one boiler horsepower	0.69

Readers should note the editorial in the Nov. 3 issue of POWER, on page 648, under the heading of "Small Leaks and Big Ones." The writer of that article not only shows his ignorance, but the tone of the article all the way through shows his disposition to injure a person with whom he was not acquainted and knows nothing of his ability whatsoever.

Note under heading of "Engineering Data" ending Feb. 28, 1911, that the average evaporation for the year equals 6.8 lb.; also that when good coal was purchased in February, 1911, and October, 1910, the evaporation averaged 8.67 lb. coal as fired.

J. E. LAWRENCE.

Chicago, Ill.

Asbestos-Packed Boiler Blowoff Cocks

All our asbestos-packed blowoff cocks were leaking badly, because the packing was worn and the stems cut. As new packing would cost within 30 per cent. as much as new cocks and believing that a good grade of babbitt would do just as well if not better, a mandrel was made, a set of cocks babbitted, the stems turned, ground in and the cocks placed in service. These worked satisfactorily and the others were repaired in the same way. The job was done by our own men and at much less cost than if sent to the factory.

It is over six months now, and they are still tight.

J. McL. BURNS.

Dover, N. J.

The Fireman Is a Chemist

Chemistry itself is without sin, but the sins of chemists are many. I note with interest a letter on this subject in the issue of Dec. 22, page 880. It is to be regretted that such a mistaken statement as "air is composed of hydrogen, oxygen and nitrogen" should have been allowed to go unchallenged, as it is a common one. It should be remembered, even by one who is not a practical chemist, that the air consists chiefly of nitrogen and oxygen, with some inactive argon, and some active carbonic-acid gas and water vapor.

I suppose the time will come when everyone will know more of the common facts accurately. Such a mistake is not only to be regretted, but it tells us that we must fight the battle for education again and again. Of course, if the air should contain any hydrogen, then the air would itself be not merely a supporter of combustion, but would be partly combustible, which, however desirable, is not the case.

The great lesson is that chemistry is something which is fundamental to almost every line of business and manufacture, and we should all learn to use it as it should be used, with safe and sane common-sense. Let the eternal battle-royal go on in the grand campaign of education. Make fun of chemists, as we fully deserve, but treat Chemistry well; she can speak for herself.

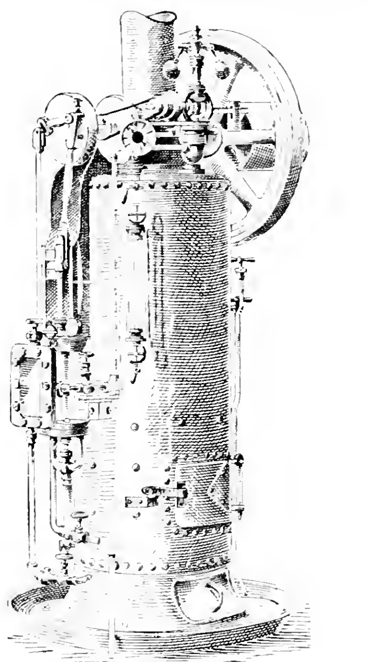
CHARLES S. PALMER.

Newtonville, Mass.

[The original was in error in a sense for it did not state that the hydrogen was not present as free hydrogen, but combined with oxygen in the form of vapor, often augmented by the use of steam jets.—EDITOR.]

Printers' Engine

In the Oct. 20 issue is an article on a self-contained steam plant which is interesting as a relic. The Buckeye Engine Co. had a similar idea and built a self-contained power plant called the "Printers' Engine." It was made in sizes from 1¼ to 15 hp. Recently some drawings which were made in 1872, showing the cylinder set in the



PRINTERS' ENGINE AS BUILT IN 1873

head of the boiler, were found at the works. The type of engine illustrated herewith, however, was successful and a number of them was sold.

D. J. McCONNELL.

Salem, Ohio. Buckeye Engine Co.

[The circular from which the accompanying illustration is produced is dated 1873.—EDITOR.]

Engineers' Study Course

Problems in Power-Plant Design—XIII

Comparing Steam Requirements with Available Exhaust

It was stated in the first article of the series that in designing a combined power and heating plant a comparison should be made between the steam requirements and available exhaust which should cover with a fair degree of accuracy the entire heating season.

In a general way, it is usually economical to employ the exhaust steam for heating purposes and to design the power plant with reference to that arrangement. Or, stated in another way, it is generally advisable, under average conditions, to install power and lighting plants in large buildings and to utilize the exhaust for heating. While this may be true ordinarily, the amount of saving will depend upon a number of conditions which may vary widely in different cases. Among these may be mentioned length of heating season, average winter temperature, type of engines used, method of heating, cost of fuel, water, labor, etc., and also, of the most importance, the relation between the steam required for heating and the available exhaust at different parts of the day.

The total exhaust from a plant in twenty-four hours may be equal to or exceed the heating requirements during the same length of time, but if it is not distributed so as to be utilized, a large amount may be thrown away at certain parts of the day which must be made up at other times by live steam taken from the boilers. From this it may be seen that total amounts of steam for the day are often misleading and a special study should be made of conditions from hour to hour (where there is much variation of load) for representative days of a considerable number of periods throughout the heating season. In the present case the available exhaust was assumed to be practically uniform throughout the year, and, furthermore, was found to exceed the heating requirements, so that a comparison of this kind was not necessary.

In other plants, especially those in office buildings, hotels, etc., where lighting and elevator service form a large part of the load, conditions will be found much more variable and tables or curves for comparison should always be prepared.

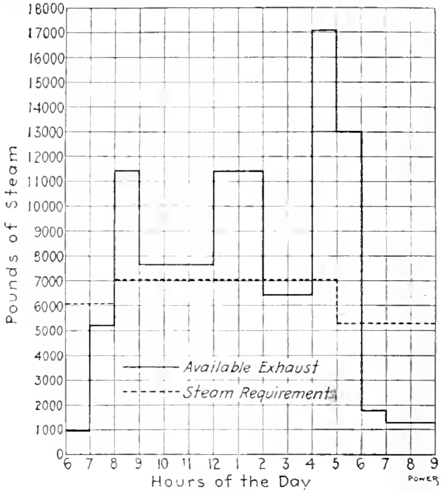
Power and Heat Requirements

In any given case the first step is to make up a schedule which shall represent the power and heat requirements for the heating season.

A good way to obtain average conditions is to divide the season into seven equal periods, extending from the middle of October to the middle of May, and from the weather records of previous years obtain the average temperature of each of these periods. If the plant is operated daytimes only, use the day temperatures, but if it is operated both day and night, as in a large hotel, then make up two lists, one of average temperatures from 6 o'clock in the morning until 6 at night, and the other for the remaining twelve hours. Designate them "day temperatures" and "night temperatures."

Next, make a list of all purposes for which steam is required in the building exclusive of that used for power. These will vary in different cases, but they will ordinarily include one or more of the following: Heating, ventilating, hot water for lavatories and baths, cooking, laundry service, sterilizing, mill work, such as drying, washing, finishing, etc., and dry kilns.

In a new plant the weight of steam required for each of the foregoing purposes per hour, with the exception of heating and ventilating, may usually be obtained from those installing the kinds of apparatus to be used. If the



problem concerns the installation of a power plant in a building already constructed and in use, tests should be made to determine the weight of steam actually required. In addition, the particular hours of the day during which steam is required for the various purposes should be noted as well as the weight used. The requirements for heating and ventilating may usually be computed with sufficient accuracy from the data given in previous articles of the present series, supplemented by certain corrections to be noted presently.

The heating system for a building is commonly proportioned for the coldest weather to which that particular locality is subject. If now the apparatus be provided with a system of automatic control, which shall gage the heat supplied to actual requirements, the weight of steam used per hour will vary directly as the difference between the inside and outside temperatures (neglecting the effect of high winds) and will change with each variation of outside temperature throughout the heating season. If, on the other hand, the entire radiating surface is kept turned on at all times or the heating plant is run at its full capacity, the weight of steam used per hour will be practically the same for all outside temperatures, with a system of direct radiation, provided the inside temperature is maintained at 70 deg. by opening the windows. As a matter of fact, neither of these conditions ordinarily prevails, although the former is very nearly approached with the best systems of pneumatic control.

To approximate the steam requirement for heating with different outside temperatures, the weight of steam used per hour in zero weather must be multiplied by a factor corresponding to the actual outside temperature, and this in turn must be corrected for the type of temperature regulation employed. Assuming that the plant is designed for a minimum outside temperature of zero and the normal inside temperature of 70 deg., and that the system is accurately controlled to maintain this inside temperature without opening the windows or admitting cool air, the proportion of heat required for varying outside temperatures will be found in Table 1.

TABLE 1. HEAT REQUIREMENTS

Outside temperature, deg. F..........	0	+10	+20	+30	+40	+50	+60	+70
Proportion of heat required, as compared with zero conditions.	1.00	0.86	0.72	0.57	0.43	0.29	0.15	0.00

For example, if 1000 lb. of steam is required for heating a given building with an outside temperature of zero only,

$$1000 \times 0.72 = 720 \ lb.$$

will be required when it is 20 deg. above, or

$$1000 \times 0.43 = 430 \ lb.$$

at 40 deg., etc. The next step is to assume certain factors to offset the steam wasted when different means of temperature regulation are employed. These factors can only be estimated, but for average conditions it may be assumed that with the best systems of automatic control the results given in Table 1 will be obtained. With forced hot-water circulation these should be multiplied by 1.2; with vacuum systems by 1.3, and with low-pressure gravity systems by 1.4.

For example, if 1000 lb. of steam is required per hour in zero weather with a low-pressure gravity system,

$$1000 \times 0.43 \times 1.4 = 602 \ lb.$$

will be required when it is 40 deg. above zero. In other words, 40 per cent. more radiation will be in use than is actually required for heating the building and the surplus heat will be wasted through open windows.

When ventilation is provided in large buildings by means of fans, the temperature of the entering air is accurately controlled, and Table 1 may be made use of, the same as for automatically controlled direct radiation. For example, if the weight of steam required for warming the air for ventilation is 3000 lb. per hr. in zero weather, it will be

$$3000 \times 0.57 = 1710 \ lb.$$

when the outside temperature is +30 deg.

After having determined the weight of steam required for all heating purposes for each hour of the average day of the first period, Oct. 15 to Nov. 15, the next step is to estimate the average indicated horsepower required for all power purposes for the corresponding period.

The power requirements will vary with the type of building and will commonly include a portion of the following: Driving machinery, lighting, elevator service, auxiliary pumps, refrigeration, ventilating fans, miscellaneous motors for kitchens, laundries, etc. As the power load will vary at different hours of the day, each hour should be taken up separately and the available exhaust computed for comparison with the steam requirements for heating during the corresponding hour. The total indicated horsepower multiplied by the water rate of the engine, and this result by 0.85, will give the available exhaust. In making a full study of this kind of problem the average day for each of the seven periods should be similarly worked out and the results either tabulated or plotted in curves for easy reference. Having shown the general method to be followed in such problems, it may be well to illustrate it by working out a simple example in detail.

Take the case of an office building requiring power for lighting, elevator service, auxiliary pumps and fan motors, and steam for heating, ventilation and hot-water service. Suppose the maximum requirements for each are found to be as follows: Lighting, 200 kw.; elevator service, 300 i.hp.; fan motors, 12 i.hp.; auxiliary pumps, 20 i.hp. All items rated in indicated horsepower are referred to the main engines and include the friction losses in the various machines. Let the period taken be from Dec. 15 to Jan. 15, when the lighting requirements are at a maximum, and assume them to be as follows:

Hour of Day	Kw.	I.Hp. at Engine
6 a.m. to 7 a.m.	10	18
7 a.m. to 8 a.m.	50	88
8 a.m. to 4 p.m.	70	124
4 p.m. to 6 p.m.	200	350
6 p.m. to 9 p.m.	40	70

In making out this schedule it has been assumed that each kilowatt delivered by the dynamo requires 1.75 i.hp. at the engine. The schedule of elevator service is assumed to be as follows:

Hour of Day	I.Hp. at Engine
7 a.m. to 8 a.m.	100
8 a.m. to 9 a.m.	300
9 a.m. to 12 noon	150
12 noon to 2 p.m.	300
2 p.m. to 4 p.m.	100
4 p.m. to 5 p.m.	300
5 p.m. to 6 p.m.	150
6 p.m. to 7 p.m.	50
7 p.m. to 9 p.m.	10

The various auxiliary pumps, including those for hot-water circulation for heating the building, are run continuously from 6 a.m. until 9 p.m. and require approximately 20 i.hp. at the main engines. Ventilation is provided for the first-floor stores and special offices and the fans are run from 8 a.m. till 5 p.m., at a uniform load of 12 i.hp. at the engine.

As the exhaust will be utilized for heating purposes, simple high-speed engines will be used having a water rate of approximately 30 lb. per hr. per i.hp., of which about

$$30 \times 0.85 = 25 \ lb.$$

will be available in the exhaust for heating purposes.

It is now possible to make out a schedule covering the entire day, giving the total indicated horsepower for all purposes and the pounds of available exhaust for each hour.

TABLE 2 SCHEDULE OF AVAILABLE EXHAUST

Hour of Day	I.Hp. for Different Purposes A	B	C	D	Total I.Hp.	Pounds per Hour of Available Exhaust (I.Hp. x 25)
6 to 7	20	+ 18			38	950
7 to 8	20	+ 88	+ 100		208	5,200
8 to 9	20	+ 124	+ 300	+ 12	456	11,400
9 to 10	20	+ 124	+ 150	+ 12	306	7,650
10 to 11	20	+ 124	+ 150	+ 12	306	7,650
11 to 12	20	+ 124	+ 150	+ 12	306	7,650
12 to 1	20	+ 124	+ 300	+ 12	456	11,400
1 to 2	20	+ 124	+ 300	+ 12	456	11,400
2 to 3	20	+ 124	+ 100	+ 12	256	6,400
3 to 4	20	+ 124	+ 100	+ 12	256	6,400
4 to 5	20	+ 350	+ 300	+ 12	682	17,050
5 to 6	20	+ 350	+ 150		520	13,000
6 to 7	20	+ 70	+ 50		140	3,500
7 to 8	20	+ 70	+ 10		100	2,500
8 to 9	20	+ 70	+ 10		100	2,500

In the above schedule column A represents power for auxiliary pumps; B. electric lighting; C. elevators; and D. ventilating fans.

The next step is to prepare a similar schedule for the heating requirements. Suppose the computations show the total heat necessary for warming the building in zero weather to be 5,700,000 B.t.u. per hr., and for ventilating purposes 2,000,000 B.t.u. per hr. Furthermore, suppose that the weather records for the past five years show the average day temperature to have been +20 deg. for this period. Let the circulating pumps for the heating system be started at 6 a.m. and stopped at 9 p.m., and assume that two hours are required for warming the building up to 70 deg., so that from 6 to 8 in the morning during this month the plant will be run at its full capacity regardless of the outside temperature. Although the building is to be warmed with hot water, the steam requirements will be the same as though it were condensed in the radiators instead of in a special heater.

Taking the latent heat of exhaust steam as 970 and the factor for hot-water regulation as 1.2, we have the following conditions and results: During the period from 6 till 8 a.m. the total capacity of the heating plant will be required and utilized, or

$$\frac{5,700,000}{970} = 5876 \ lb.$$

or practically 5900 lb. of steam will be used per hour. For the remainder of the day this will amount to

$$5900 \times 0.72 \times 1.2 = 5097 \ lb. \ per \ hr.$$

Heat for ventilating purposes amounts to

$$2,000,000 \times 0.72 \times 1.2 = 1,728,000 \ B.t.u.$$

$$\frac{1,728,000}{970} = 1781 \ lb. \ per \ hr.$$

from 8 a.m. till 5 p.m. Buildings of this kind are usually supplied with a hot-water storage tank so that any variation in the demand for hot water during the day is cared for in this way.

In the present case, steam will be on the tank continuously from 6 a.m. till 9 p.m. and it may be assumed that 150 lb. of steam per hour is required for this purpose throughout the day. The data are placed in tabular form, the same as for the power requirements, in Table 3.

TABLE 3. SCHEDULE OF STEAM REQUIREMENTS

Hour of Day	Lb. Steam per Hr. for Heating	Lb. Steam per Hr. for Ventilation	Lb. Steam per Hr. for Hot Water	Total Steam Requirements, Lb. per Hr.
6 to 7	5,900	.....	150	6,050
7 to 8	5,900	.....	150	6,050
8 to 9	5,097	1,789	150	7,036
9 to 10	5,097	1,789	150	7,036
10 to 11	5,097	1,789	150	7,036
11 to 12	5,097	1,789	150	7,036
12 to 1	5,097	1,789	150	7,036
1 to 2	5,097	1,789	150	7,036
2 to 3	5,097	1,789	150	7,036
3 to 4	5,097	1,789	150	7,036
4 to 5	5,097	1,789	150	7,036
5 to 6	5,097	.	150	5,247
6 to 7	5,097		150	5,247
7 to 8	5,097		150	5,247
8 to 9	5,097		150	5,247

As a matter of fact, the outside temperature will vary more or less during the day, but as this is so irregular in its action it is difficult to allow for it unless the number of hours for each temperature is tabulated. For approximate work it is usually sufficiently accurate to use constant temperatures throughout the day and night periods. In the present case a constant temperature has been assumed for the entire heating period from 6 a.m. till 9 p.m. Table 4 compares steam requirements and available exhaust and shows the weight of live steam required and exhaust wasted for each hour during the day.

TABLE 4. SCHEDULE OF COMPARISONS

Hour of Day	Steam Requirements, Lb.	Available Exhaust, Lb.	Live Steam Used, Lb.	Exhaust Wasted, Lb.
6 to 7	6,050	950	5,100	....
7 to 8	6,050	5,200	850	..
8 to 9	7,036	11,400	.....	4,364
9 to 10	7,036	7,650	.....	614
10 to 11	7,036	7,650	.....	614
11 to 12	7,036	7,650	.....	614
12 to 1	7,036	11,400	.....	4,364
1 to 2	7,036	11,400	.....	4,364
2 to 3	7,036	6,400	636	.....
3 to 4	7,036	6,400	636	.....
4 to 5	7,036	17,050	....	10,014
5 to 6	5,247	13,000	....	7,753
6 to 7	5,247	3,500	1,747	.....
7 to 8	5,247	2,500	2,747	..
8 to 9	5,247	2,500	2,747	.....
Total	96,412	114,650	14,463	32,701

Referring to Table 4, it is seen that while the available exhaust for the day is

$$114,650 - 96,412 = 18,238 \ lb.$$

more than the total steam requirements for heating, it is so distributed that 32,701 lb. are wasted and 14,463 lb. of live steam must be taken from the boilers to make up the deficiency. This illustrates the point noted at the beginning of the article—that total steam quantities for the day should not be relied upon when making comparison of steam requirements and available exhaust. To make the comparison complete, this same process should be gone through with for an average day for each month of the heating season.

In large plants, where there is considerable variation in power and heating conditions from month to month, it may be advisable to take shorter periods, say every week or ten days. The accompanying diagram is a plot of the heat requirements and the available exhaust. This shows at a glance the relation of one to the other throughout the day.

American Association for the Advancement of Science

The 66th meeting of the American Association for the Advancement of Science held at Philadelphia, Penn., Dec. 28, 1914, to Jan. 2, 1915, was attended by 1500 to 2000 members and guests coming from every part of the United States. Nearly every university, Federal department, state or city government which employs scientific investigators was represented and the Philadelphia meeting recently brought to a close was undoubtedly the most successful in scope of subjects and in point of attendance of any since the organization of the association in 1847.

There are 12 sections of the association, comprising mathematics and astronomy, physics, chemistry, engineering, geology and geography, zoology, botany, anthropology and psychology, social and economic science, physiology and experimental medicine, education, agriculture.

The programs of the different sections each included anywhere from five to one hundred addresses and communications in their respective fields of scientific research. The sections and 24 affiliated societies held their principal sessions in the various halls, lecture rooms and laboratories of the University of Pennsylvania, which afforded admirable accommodations. Dr. Charles W. Eliot, president emeritus of Harvard University, was elected president of the association for the ensuing year. At the first general session the retiring president, Dr. Edmund D. Wilson, in delivering his annual address, said that "the scientific method is the mechanistic method which produces practical results. The moment we swerve from it by a single step we set foot on a foreign land."

Frederick W. Taylor, one of the vice-presidents of the association, presided at the sessions of the engineering section which were held Dec. 30 and 31 in the Engineering Building of the university. Seventy-five papers and addresses were presented on various subjects of industrial, hydraulic and civil engineering, the latter including 30 papers on highway construction and pavements.

The next regular meeting of the association will be held at San Francisco, Calif., Aug. 2 to 7, 1915. As this will be during the Panama-Pacific Exposition, it is expected that the meeting will be largely attended.

Testing Liquid Flow Meters*

By W. S. Giele

SYNOPSIS—Description of a laboratory for testing and calibrating liquid flow meters by means of direct comparison of like quantities, such as volumes, inches of water head, and rates per unit time.

The laboratory herein described was designed and built to facilitate the investigation and testing of liquid flow meters, with special reference to those of the V-notch weir type. This type consists essentially of a rectangular chamber containing a vertical dividing wall with a V-notch weir plate attached to the upper part. On one side is the "approach" chamber provided with suitable baffles, and on the other, the "outflow" chamber which receives the discharge of the notch, and from which water passes to boiler feed pumps or other places of delivery. This meter is provided with an autographic recording device, giving a continuous record from which the instantaneous rate of flow may be read, while also permitting a continuous integration of quantity.

The indicating, recording and integrating instruments will be best understood by reference to Fig. 1. A float in either

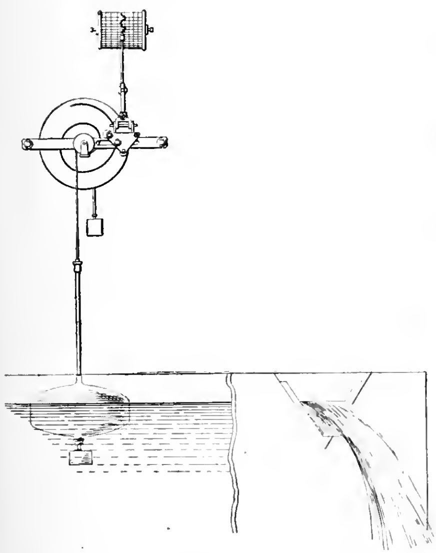


Fig. 1. Recording Devices

the approach chamber or a chamber in communication therewith, bears a vertical stem, actuating (by means of a cable and drum) a revolvable cam, which is adapted to displace a pen carriage or integrating train equal distances for equal increments in the rate of flow. For convenience in manufacture and use, it is desirable that one standard height of chart be employed for all capacities, and that this chart be subdivided decimally. With arbitrarily selected weir-notch angles this might be attained by cutting a different cam for each capacity, but it is much easier to use one standard cam, embodying the relation between the rate of flow and the head of water on the notch, and to accomplish the adaptation to different rates of flow by varying the diameter of the cable drum and the angle of the notch itself; thus making it necessary to establish accurately the relation between the coefficient of the notch and the angle.

The method decided upon was to construct a master flow meter so arranged that the rate of flow could be maintained accurately at any desired value for long periods; and after having determined with precision the performance of this standard, to use it as a means of measuring the flow through the meters which it is desired to investigate.

By this means of direct comparison, a degree of accuracy can be secured in the meter under test practically equal to that of the standard. Such a standard having once been accurately calibrated, disturbing influences arising from the effects of proportions of the channel of approach, conditions

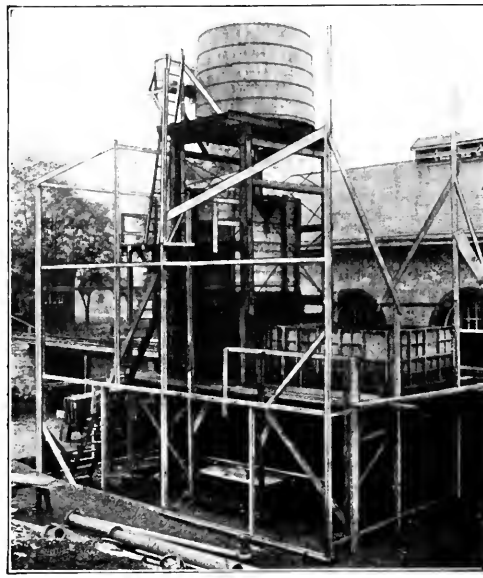


Fig. 2. General View of Meter-Testing Plant

of surfaces, form and material of notch, directions and interference of currents of flow in the channel of approach, etc., can be ignored.

It is estimated that by this method greater accuracy can be obtained in a run of one-half hour at a low head than would be possible in a run of fifteen hours at the same head, using either volumetric or gravimetric methods.

Description of Apparatus

As shown in Figs. 2 and 3, the testing plant has a large storage tank from which the water is drawn by a pump and elevated to a supply or constant-head tank at the highest level, its purpose being to supply water to a discharge orifice at a constant head so that the rate of flow through the standard notch may be maintained invariable at any desired capacity.

From the constant-head tank the water passes to the standard-notch tank, thence flows over the calibrated notch into the meter under test, whence it is discharged to the storage tank to circulate again.

During the preliminary work on the calibration of the standard notch, instead of passing from the standard notch to the meter under test, the water flowed alternately to either of two volumetric measuring tanks, from which it discharged into the storage tank to resume its course.

In view of the necessity for permanent maintenance of conditions under all circumstances, the entire plant was constructed with the utmost regard to permanency and rigidity. The foundation consists of a concrete slab approximately 24 ft. long by 10 ft. wide, carried to solid clay soil and reinforced in all directions by 1-in. rods.

The storage tank rests directly on the concrete foundation and holds a little over 1000 cu.ft. of water. The supply to the pump is through an 8-in. opening located with its center

*Excerpts from a paper before the American Society of Mechanical Engineers, at New York, Dec. 4, 1914.

about 8 in. above the bottom of the tank (to eliminate sludge which might accumulate on the bottom), and 12 in. from the vertical center line of the end of the tank. It is also supplied with a 3-in. drain at its lowest point and with a system of steam pipes whereby the water may be heated to the desired temperature.

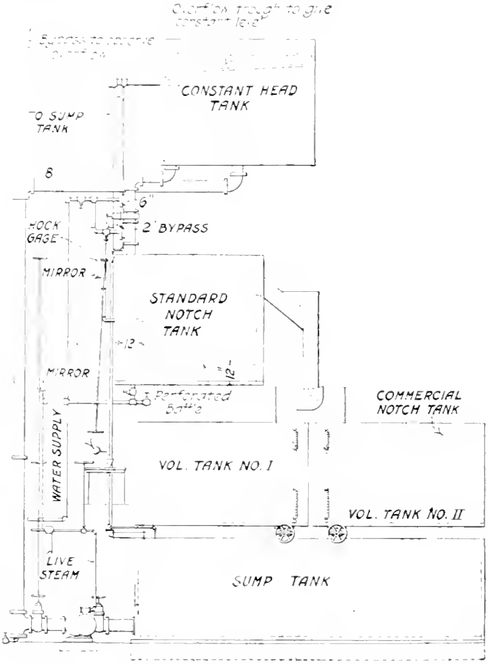


Fig. 3. Elevation of Testing Plant

The pumping unit is an 8-in. single-stage, centrifugal pump about 4 ft. from the end of the storage tank. It is gear-driven by a single-stage steam turbine, and has a capacity of about 120 cu.ft. per min. against the head of the highest tank, which corresponds to a flow of about 450,000 lb. per hr.

The outlet from the constant-head tank is a 6-in. line taken from the bottom and as close to the side as possible. This arrangement was adopted after experiments looking toward the prevention of a swirling motion within the tank.

The maintenance of a practically constant head in this tank is essential to a constant flow through the system. This is accomplished by the installation of an overflow weir consisting of a rectangular trough 8 ft. 8 in. long, having inflow edges or weirs on both sides. These edges are constructed of metal and were carefully brought into a horizontal plane so that the discharge would be uniform throughout their length. The overflow at these edges is carried by a 4-in pipe line back to the storage tank, this line being provided with a ½-in. bypass discharging into open funnels on both the standard notch level and the observation room level so that the observer may constantly watch the overflow and thereby judge of the constancy of the head.

The approximate amount of water in the constant-head tank is indicated by a float to which is attached a chain passing over sheaves and extending to the pump room with pointers at each level.

The outlet pipe for the constant-head tank into the standard-notch tank contains a 6-in. valve for roughly setting the larger flows and a 2-in. valve in a bypass carried around the 6-in. valve for fine adjustment. The stem of this 2-in. valve is carried down to the observation station so that the flow may be accurately controlled from that point.

Every precaution has been taken to prevent change in shape or position of the standard notch. It rests on a structural steel platform supported by heavy, rigidly braced columns carried outside the volumetric measuring and storage tanks directly to the foundations, the column loads being distributed on the foundation by two 15-in. I-beams, grouted in. The standard V-notch is approximately 22½ in. high by 11¼ in. wide at the top, and its full capacity at 18¼ in. head is roughly 110 cu.ft. per min.

The standard-notch tank is divided into two compartments by a rigid partition 1 ft. from the end opposite the notch and ending 1 ft. above the bottom. The supply line discharges behind this partition 2 ft. below the surface of the water, and the water finds its way under the partition, spreads out over the bottom of the tank and rises through a perforated baffle having approximately 2000 holes ¾ in. square. This arrangement has resulted in a quiet surface of approach, even at the highest rates of flow.

It was not necessary to find the apex or zero level of the standard notch with extreme precision, it being necessary only to provide a reference point from which measurements could always be taken, and which would be immovable with respect to the notch itself. This reference point consists of a hook gage securely soldered to the notch with its point in a plane normal to the plane of the notch through its vertical center line and ½ in. away from it. The level of the water above the zero level is read by a second adjustable hook gage attached to the opposite end of the tank.

As any tilting of the tank would not only change the cross-section of the stream issuing from the notch, but also the relation between the hook gage by which the level is read and the notch, the care in supporting the tank is further checked by means of special gages to indicate any deflection in the tank or supports. These special gages consist of four glass tubes with three reference lines, spaced 9 in. apart, etched entirely around each. The four gage glasses are firmly attached at the four corners of the standard-notch tank.

The level of the water flowing through the standard-notch is obtained by means of a specially designed hook gage connecting with the still-water chamber. The special and unusual construction of this hook gage arises chiefly from the extreme range of height which it must cover and the consequent possibilities of error resulting from differences in temperature between the various parts of the gage itself at various times, and also between the water column within the gage tube and the temperature of the water in the still-water chamber. To eliminate the effect of temperature changes in the gage itself, the elements were so constructed that expansions due to increased temperature would tend to compensate each other. To eliminate the effect of differences of temperature between the two water columns, the hook gage tube was jacketed by flowing water taken from the same source of supply as that to the still-water chamber. The hook itself has a 60-deg. point and is constructed as shown in Fig. 4.

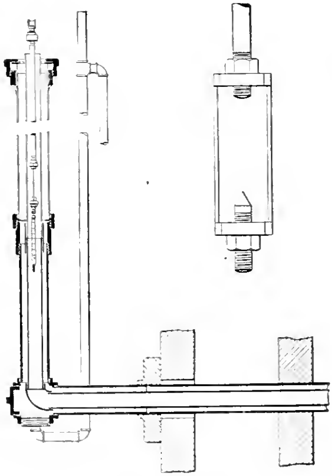


Fig. 4. Showing Arrangement of Hook Gage

The register of the point of the hook with the surface of the water is observed from below the water surface, in which position it is possible to see both the hook itself and the reflected image on the surface of the water. The hook is at the water surface when the point of the reflected image coincides with the point of the hook. Any deviation from this position is observed as double the distance between the point of the hook and the water surface, thus permitting exactness in this observation, which is further promoted by the fact that the reading is taken through a magnifying lens and reflected downward and horizontally by a mirror to the observation station, at which point a four-power binocular is rigidly supported for observation. The hook is illuminated by means of a frosted incandescent bulb.

Owing to the number of readings to be taken and the space covered by the plant, special means were necessary to bring all observations and controls to a central observation station. Fig. 5 is an interior view of the observation room showing the desk from which observations are taken.

When running tests, it is necessary only to observe that the water level remains at the point of the hook and it is not necessary to read the height of the hook gage on the standard-notch tank during the progress of an experiment. A similar hook gage is applied to the meter under test with the addition of an extended shaft bringing the graduated scale to the observation room where the operator can read the height of water passing over the weir under test. This reading is taken immediately above the eye pieces of the binoculars through which is observed the coincidence of the water surface and the hook.

It was determined after several experiments that the hook and hook rod must be relieved of all strains and left free to align themselves by gravity. While with the jacketed

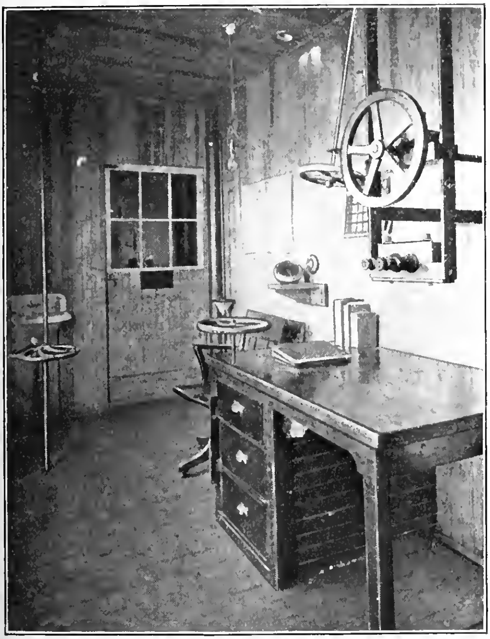


Fig. 5. Observation Room

arrangement it was never possible to detect a difference in temperature between the water in the hook gage tube and in the still-water chamber exceeding ½ deg. F. during the course of a whole day, it is interesting to note the results which might be obtained from an unjacketed gage. Without the jacket water it was found that a difference of 20 deg. F. (from 50 to 70 deg.) was entirely possible and effected a vertical head of 30 in. of water. The reading of the gage under such conditions would be 0.018 in. in error.

In investigating the effects of temperature changes on the parts of the gage it is to be noted that the vertical sheave support in its expansion will compensate for the elongation of the cable due to temperature, and that the expansion of the drum will tend to compensate for the elongation of the hook rod between the point of the hook and the attachment of the cable.

In preparing for the calibration of the standard notch, a curve was plotted, indicating the ideal conditions of flow, which the experiments would approximate. This curve was then divided into sections so that these could be separately plotted from the empirical data obtained to a much larger scale. After having mapped out the points it was desired to plot on the curve it was necessary only to set the hook gage at heads corresponding to these points and start the circulation of water through the system. After bringing the flow up to the desired head by manipulation of the control valves, readings were taken at regular and frequent intervals, until a sufficient number had been obtained showing uniform conditions, to furnish data for the necessary computations with assurance of reliability.

Municipal Plant Not to Extend Service

A recent bill passed by the city council of Seattle to permit the municipal lighting plant to extend its service beyond the city limits to serve rural districts has been vetoed by the mayor. The council refused to pass the bill over the mayor's veto. In refusing to adopt the plan of extending the city lighting system to outlying communities, Mayor Gill said in part:

"To say that the Seattle lighting plant is a money-making concern in the sense that it earns money for the general purpose of reducing taxation is wrong. From its inception the lighting plant has controlled the rates of this city. It has saved our business men, taxpayers and residents many millions of dollars and will continue to do so unless it is brought into disrepute and made a political plaything.

"Under this theory of outside extensions there is no reason why the city of Seattle should not engage in any other commercial business and conduct grocery stores, drygoods stores and other profit-making concerns. All there is embodied in this bill is pure socialism and opportunity given to settle the grudges of certain persons arising from real or imaginary grievances against a private corporation.

"The financial condition of our lighting plant at the present time is due to gross financial mismanagement by the council for the past three years. The councilmen refused to comply with the recommendations of former Chief of Police Griffiths and myself, and light downtown alleys, giving as an excuse that they had no money, although they are now preparing to become 'wet nurse' for the suburban districts outside the city limits, and are far worse off financially now than then. I have always maintained that the plant should seek a fair return on the money invested and the amount so earned be expended within the limits of the city to the end that all our people should have light at the lowest cost consistent with good business management.

"The tax rate of the city during the past few years has increased at a highly unprecedented rate, and we have nothing to show therefor except a street car line which was not intended to accommodate the public and which did not even accomplish the purpose of is principal promotors. As a matter of fact, there is no money in the light fund."

Research Fellowships at Illinois University

To extend and strengthen the field of its graduate work in engineering, the University of Illinois has since 1907 maintained ten research fellowships in the engineering experiment station. These fellowships, for each of which there is an annual stipend of $500, are open to graduates of approved American and foreign universities and technical schools. Appointments are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the master's degree will be granted. Not more than half of the time of the research fellows is required in connection with the work of the department to which they are assigned, the remainder of the time being available for graduate study.

Nominations to fellowships, accompanied by assignments to special departments of the engineering experiment station, are made from applications received by the director of the station each year not later than the first day of February. These nominations are made within the month of February by the station staff, subject to the approval of the faculty of the graduate school and the president of the university. Appointments are made in March, and they take effect the first day of the following September.

Nominations are based upon the character, scholastic attainments, and promise of success in the principal line of study or research to which the candidate proposes to devote himself. Preference is given those applicants who have had some practical engineering experience following their undergraduate work. Research work may be undertaken in architecture architectural engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and in theoretical and applied mechanics. The work of the station is closely related to that of the college of engineering, and the heads of departments in the college constitute the administrative station staff. Investigations are carried on by the members of the staff and other members of the instructional force of the college of engineering, by special investigators employed by the station, and by the research fellows. Four vacancies are to be filled at the close of the current academic year. Additional information may be obtained by addressing the director of the engineering experiment station, University of Illinois, Urbana, Ill.

3000-Volt Direct-Current Electrification

Plans for the electrification of the Puget Sound lines of the Chicago, Milwaukee & St. Paul Ry. have now been completed and contracts let to the General Electric Co. for the electric locomotives, substation apparatus and line material, and to the Montana Power Co. for the construction of the transmission and trolley lines. This initial electrification of 113 miles of main line between Three Forks and Deer Lodge is the first step toward the electrification of four engine divisions extending from Harlowton, Mont., to Avery, Idaho, a total distance of approximately 440 miles. Later on, it is understood, the electrification will extend to the coast.

The Montana Power Co. covers a large section of Montana and part of Idaho with its network of transmission lines, which are fed from a number of sources of which the principal ones are:

Madison River	11,000 kw.
Cañon Ferry	7,500 kw.
Hauser Lake	14,000 kw.
Big Hole	3,000 kw.
Butte (steam turbine)	5,000 kw.
Rainbow Falls	21,000 kw.
Small powers aggregating	7,390 kw.
Total developed	68,890 kw.

Further developments, part of which are under construction, are:

Great Falls	85,000 kw.
Holter	30,000 kw.
Thompson Falls	30,000 kw.
Snake River	20,000 kw.
Missoula River	10,000 kw.
Total	175,000 kw

Total capacity developed and undeveloped 244,000 kw

The several power sites are interconnected by transmission lines, operating at 50,000 volts for the earlier installations and at 100,000 volts for later installations.

The railway company will purchase power at a contract rate of $0.00536 per kw.-hr., based on a 60 per cent. load factor. It is expected under these conditions that the cost of power for operating the locomotives will be considerably less than is now expended for coal.

In order to connect the substations with the several feeding-in points of the Montana Power transmission lines, a tie-in transmission line is being built by the railway company that will permit feeding each substation from two directions and from two or more sources of power. This transmission line will operate at 100,000 volts.

The immediate electrification will include four substations containing step-down transformers and motor-generator sets with necessary switchboard apparatus to convert 100,000-volt, 60-cycle, three-phase current to 3000 volts direct current. This is the first direct-current installation using such a high potential as 3000 volts, and this system was adopted in preference to all others after a careful investigation extending over two years.

SUBSTATIONS

The substation sites of the electrified zone provide for an average intervening distance of approximately 35 miles.

The substations will be of the indoor type, with three-phase, oil-cooled transformers reducing from 100,000 to 2300 volts, at which potential the synchronous motors will operate. The transformers will be rated 1900 and 2500 kv.-a. and will be provided with four 2½ per cent. taps in the primary and 50 per cent starting taps in the secondary.

The motor-generator sets will each comprise a 60-cycle synchronous motor driving two 1500-volt direct-current generators connected permanently in series for 3000 volts. The fields of both the synchronous motor and direct-current generators will be separately excited by small generators direct-connected to each end of the motor-generator shaft. The generators will be compound wound, will maintain constant potential up to 150 per cent. load and will have a capacity for momentary overloads of 300 per cent. normal rating. To insure good commutation on these overloads, the generators will be equipped with commutating poles and compensating pole-face windings. The synchronous motors will also be utilized as synchronous condensers, and it is expected that the transmission line voltage can be so regulated thereby as to eliminate any effect of the fluctuating railway load.

Water-Power Bills before Congress

There were two bills introduced during the session of Congress just closed, each of which is of considerable importance and will have a controlling influence over future water-power projects if enacted into law. On careful reading, there seems to be no conflict of purpose at present or likely to arise from the enaction of both bills.

The Adamson bill deals exclusively with navigable waters, consequently with projects of considerable magnitude, while the Ferris bill deals with water-power development within the public lands and reservations of the United States. The Adamson bill, the first introduced, is an act to amend "An act to regulate the construction of dams across navigable waters," approved June, 1906, amended June, 1910, and is in general terms as follows: Authority is vested in the Secretary of War and the chief of engineers of the War Department to grant persons of proper status the right to construct and maintain a dam across or in any of the navigable waters of the United States, after obtaining approval of the plans, on condition that such persons shall maintain without expense to the United States such locks, booms, sluices or other structures which may then be deemed necessary. Also in case of future necessity, the grantee must furnish free water power or power generated from water power for the use of the United States for such construction. Provision is made for certain reimbursement to the United States for expenses incurred with reference to the project and also for funds to restore conditions whenever it shall be determined that navigation has been injured. It specifically states that the interests of navigation shall be paramount to the use of such dam for power purposes and that the grantee at his own expense shall maintain necessary lights and signals to aid navigation and such fishways as shall be prescribed by the Secretary of Commerce.

That persons constructing or maintaining any dam, etc., shall be liable for damage to private property by overflow or otherwise.

It shall be a misdemeanor punishable by a fine not exceeding $1000 a month to fail or refuse to comply with the lawful order of the Secretary of War, and if such failure or refusal is continued, all rights shall be revoked by a decree of the court. If such dam be declared an unreasonable obstruction to navigation its removal may be ordered at the expense of the grantee. The rights granted under this act shall continue for a period of 50 years after the completion of the dam, and after the expiration of that time such rights shall continue until compensation has been made for a fair value of the property as Congress may deem wise, unless revoked for cause.

After the expiration of 50 years, and on giving notice of one year, the United States may take over all of the property upon paying the fair value, together with the cost to the grantee of the locks or other aids to navigation and all other capital expenditures. The fair values shall be determined by an agreement between the Secretary of War and the owners, or by legal proceedings instituted by the United States, but no claim for the franchise, good will or pending contracts shall be made.

Provision is made to regulate the charges for service to the customers which shall be just and reasonable, and discriminatory charge is specifically prohibited and declared to be illegal. The Secretary of War is empowered to prescribe what shall be the just and reasonable rates in certain states, and in case of violation, certain provisions relative to forfeiture are applied. The valuation for rate-making purposes is to be based on all capital and expenditures required. The jurisdiction of the Secretary of War is provided only for states not provided with adequate laws for the regulation of rates, etc.

Another provision is that no works constructed under the provision of this act may form a part of or in any manner affect a combination or an unlawful trust, but it shall be lawful for different grantees to exchange and interchange current, to assist one another whenever necessary under regulations prescribed by the Secretary of War, but in no case to raise the price or operate in restraint of trade.

This act shall not apply to irrigation or power dams or other projects under the jurisdiction of the Secretary of the Interior or the Secretary of Agriculture upon public lands of the United States.

The Ferris bill vests in the Secretary of the Interior authority to lease to citizens of the United States, or those who have declared their intention to become such, for a period not longer than 50 years, the right to construct and maintain dams, etc., for the generation and distribution of hydro-electric power when the project will not injure a forest or national reservation. It gives preference to developments by states, counties, etc., for municipal uses and purposes, and also specifies that the lessee shall at no time, without the consent of the Secretary of the Interior, contract for the delivery to any one customer of electric energy in excess of 50 percentum of the total output. The physical combination of plants may be permitted in the discretion of the Secretary, but combinations to limit the output of electrical energy, to restrain trade or increase prices are forbidden, and, except upon written consent of the Secretary of the Interior, no sale or delivery of power shall be made to a distributing company, except in case of emergency, and then only for a period not exceeding 30 days.

Upon not less than three years' notice prior to the expiration of the lease, the United States may take over the properties upon condition that it shall pay the actual cost of the various items and the reasonable value of all property taken over, the value to be determined by mutual agreement between the Secretary of the Interior and the lessee. Such value shall not include the franchise, good will or other intangible elements. In the event the United States does not take over the properties a new lease may be granted.

For the occupancy of public lands, the Secretary of the Interior is authorized to collect charges or rentals, the proceeds to be paid into the reclamation fund under the Reclamation act, and upon the return to the reclamation fund of such moneys, 50 percentum shall be paid by the Secretary of the Treasury to the state within the boundaries of which the hydro-electric power is generated, said moneys to be used by the state for the support of public schools or for public improvements. Leases by municipal corporations solely for municipal use shall be issued without rental charges, and leases for development not in excess of 25 hp. may be issued to individuals or associations for domestic, mining or irrigation use without charge.

In states not provided with a commission to regulate rates, the Secretary of the Interior shall be vested with power to regulate such rates until such a time as the state shall provide a commission.

Where the Secretary of the Interior determines that land values will not be materially injured, power projects will be permitted, where rights now granted for the use of public lands for the purpose of irrigation or mining alone are not abridged.

The Secretary of the Interior is authorized to examine the books and accounts of lessees and require reports upon oath, and making false statements is subject to punishment as for perjury.

The final provision is made for the transfer of permits under the provision of any previous law to the present one.

Boiler and Stoker Test from Banked Fire

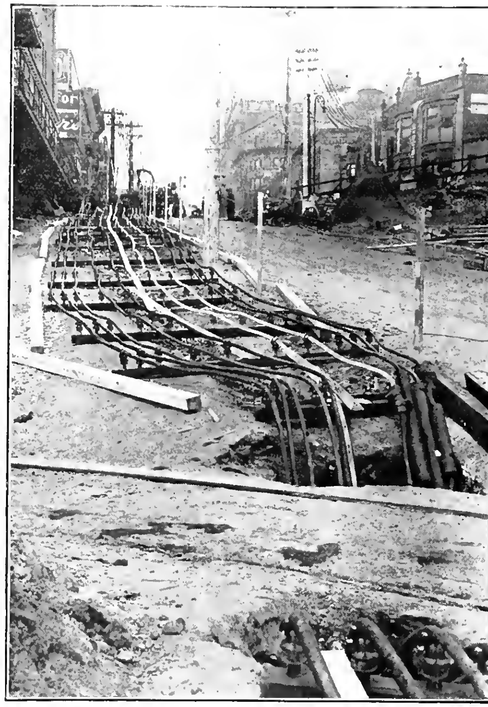
In a test made recently at the Scott Street steam station of the Toronto Electric Light Co., Ltd., Toronto, Canada, a 554-hp. Babcock & Wilcox boiler equipped with a Riley stoker was brought up to 354 per cent. of its rating in seven minutes. This performance was made possible by the moving grates of this type of underfeed stoker. The fire at once becomes active, because when starting up the stoker the moving grates also start, breaking up the fuel bed so that the air enters quickly for active combustion.

Before starting this test the boiler pressure was just below the normal pressure of 150 lb., and sufficient coal was being fed to maintain this condition. The signal to start the stoker fan was given when the steam pressure had dropped 5 lb. below normal, and this was taken as the time of starting the test. The load on the boilers was figured from switchboard kilowatt reading, figuring back through the turbine water rate, corrected for radiation losses. The turbine water rate was checked by a hot-water meter in the feed line. The turbine was called in at 9:36 a.m.; reported ready for load 3¾ minutes later. It was synchronized 41½ minutes past 9, but the stoker fan had started at 9:39. At 9:44 the load was 900 kw., equivalent to 95 per cent. of the boiler rating. Then the load went to 1700 kw., which was equivalent to 201 per cent. of the boiler rating, and at 9.46, seven minutes after the stoker and fan started, the load was 3000 kw., or 354 per cent. of the boiler rating.

This plant is used as a standby for the hydroelectric power generated at Niagara Falls. It is maintained with live banked fires in readiness to pick up the load in case of interruption to the hydro-electric power supply. This steam station contains four 554-hp. water-tube boilers, each equipped with a six-retort Riley self-dumping underfeed stoker. Forced draft for the stokers is supplied by a blower directly connected to a 125-hp. direct-current motor.

Temporary Repair Work at Cleveland

Following the fire in the three manholes and 150 ft. of feeder ducts, which temporarily paralyzed electric service in Cleveland's business district, as reported in the Dec. 29 issue, the Cleveland Electric Illuminating Co. took vigorous measures to restore service. The photograph shows the temporary cables with cross-arm spacers laid on the ground over Vinegar Hill. The cross-arms were later raised 30 in. above the ground. These temporary cables follow the line of the burned out ducts, which were immediately below, and were spliced onto the undamaged ends of the power-house feeders, it



TEMPORARY FEEDERS

being necessary to tear out a part of the duct line to get at these as the nearest manhole was badly damaged.

In addition to these a temporary overhead line of 10 cables was strung from the terminal pole, over Ontario St., and down to a manhole where connection was made with undamaged underground feeders.

The trouble occurred at 2 a.m., Wednesday (Dec. 16), and partial service was restored to some sections by noon, but it was not until Friday night that full service was restored.

"Made in the U. S. A." Exposition

The "Made in the U. S. A." Industrial Exposition, to be held in the Grand Central Palace, New York, from Mar. 6 to 13, will be national in its scope and will embrace an extensive and comprehensive exhibition of important American manufactures in all lines of trade and industry. Its dates have been selected to show distinctly American products in New

York at a time when the city is the Mecca of buyers from all sections of the country in many different lines of trade, and special efforts are being made by leading export and other associations to bring South American and other foreign buyers to the city at this time.

This exposition is the outgrowth of the work of the committee organized by Joseph Hartigan, commissioner of weights and measures of the City of New York, and the organization of the exposition, which means so much to American trade, is in the hands of Harry A. Cochrane, one of the most successful organizers and managers of American trade shows and industrial expositions. The exposition is designed to answer a twofold purpose—to stimulate and increase the sales of American-made goods to our own and foreign buyers and also to educate the American public to the resources and productions of our manufacturers and show them the goods they can obtain in this country that they have heretofore purchased from abroad.

High-Tension Feeders Cause Subway Accident

The most disastrous accident in the history of the New York subway system occurred during the rush hour Wednesday morning, when twenty 11,000-volt feeders let go in two manholes adjacent to the tracks at Fifty-third Street.

Practically the entire system was tied up and several thousand people held in the trains. The smoke and fumes from the burning insulation pervaded the subway for considerable distance, resulting in the death of one person and rendering over two hundred people unconscious. Quick response was made by the hospitals and the fire department and all the available pulmotors were put into service. The firemen ripped off the sheet-iron pans and gratings, normally used for ventilation, and rescued many through these openings to the street.

A thorough investigation is under way by both the company and the Public Service Commission as to the initial cause of the disaster, and the report will be awaited with interest; for this is the second time within a month that feeders have failed with disastrous consequences, the other being in Cleveland as reported in our Dec. 29 issue.

OBITUARY

WALLACE W. MANNING

Wallace W. Manning, chief inspector for the New York branch of the Hartford Steam Boiler Inspection & Insurance Co., died of pneumonia, Sunday, Dec. 27, 1914, after an illness of about a week, at his home, 66 87th St., Brooklyn, N. Y., aged 34 years. He was born in Cincinnati, and had lived in Brooklyn for about 20 years, 16 of which were spent with the Hartford company. He was chief inspector for six years.

Mr. Manning was the son of Mr. and Mrs. John Howard Manning, who survive him, as does his widow, Margaret Manning, two children, Howard and Ward, and a sister.

Funeral services were held at 8 o'clock Wednesday night at his late residence, and the interment took place Dec. 31.

WILLIAM N. SMITH

William N. Smith died at his home, 380 Fifth St., Brooklyn, N. Y., on Jan. 3. Mr. Smith was born in Scotland 63 years ago and had made his home in Brooklyn for 43 years. He was the engineer at the Brooklyn Bridge power house for nearly 40 years, and was transferred only when that station was abandoned. He was well known in engineering association circles and had a host of friends. He was a past-vice-president of Brooklyn Association No. 8, N. A. S. E., past-president of the Modern Science Club, chairman of the Combined Associations of Engineers of Brooklyn for five years, a member of Melville Council No. 9, Universal Craftsmen, and the International Union of Steam and Operating Engineers. Mr. Smith was also past-master of Lexington Lodge No. 319, F. and A. M., and a member of the Masonic Veterans' Association, and Bridge Council No. 49, New York Civil Service Association. He leaves a widow, two sons and seven daughters. The funeral services were held at his late residence on Tuesday evening, Jan. 5, and were attended by delegations from the several organizations above mentioned. Interment was at Greenwood Cemetery on Wednesday at 2 p.m.

PERSONALS

Heinrich J. Freyn has resigned as third vice-president of H. Koppers Co., Chicago, effective December 1, 1914.

Paul H. Brangs has been elected a director of the Heine Safety Boiler Co. to fill the vacancy caused by the death of Colonel E. D. Meier. Mr. Brangs is manager of the New York office.

Prof. John J. Flather, head of the department of mechanical engineering of the College of Engineering of the University of Minnesota, is spending a year's leave of absence in Scotland.

Prof. W. H. Kavanaugh, head of the experimental department of the College of Engineering of the University of Minnesota, has been elected chairman of the Minnesota section of the American Society of Mechanical Engineers.

Arthur G. McKee announces that Robert E. Baker and Donald D. Herr, his business associates during a number of years past, have joined with him in the incorporation of his engineering and contracting business under the name of Arthur G. McKee & Co.

Maxwell Carson Maxwell, for the past seven years head of the Department of Applied Mechanics, Pratt Institute, Brooklyn, New York City, is now superintendent of power and plant of the Yale & Towne Manufacturing Co., Stamford, Conn. He is responsible for the power generation and distribution, building maintenance, new building construction, general repairs and maintenance of machinery, shafting, etc., and also has charge of the tool department.

ENGINEERING AFFAIRS

Washington University's Lectures on Public Utilities

The appointment of James E. Allison, some time chief engineer of the St. Louis Public Service Commission, as lecturer in economics in Washington University, is of particular interest to the students of engineering in the University. During the second semester of the current year, Mr. Allison will deliver a course of lectures, under the general direction of the department of economics, which will deal with the economic principles underlying the regulation of public utilities. Some of the specific problems to be studied are the organization and operation of public utility corporations, their securities and the methods of financing them, and especially the method of valuing public utility properties for taxation and rate regulation. Seniors in the School of Engineering will now be required to take this new course which will replace in part the second semester's work in general economics. It is believed that this course presents an unusual opportunity, both because of the importance of the subject and the high standing of the lecturer.

In order to further encourage the study of economics by students of engineering of Washington University, Mr. Allison has established a fund, to be known as "The Allison Fund," the annual income of which is to be used either for awarding cash prizes or in such manner as in the opinion of the dean of the School of Engineering and the head of the department of economics will best promote the object of the fund. When a prize is offered, competition will be open to the students of engineering who undertake a special investigation of the field of public utilities under the direction of the department of economics, with such restrictions as to eligibility as may be specified from time to time.

BOOKS RECEIVED

PRACTICAL LESSONS IN ELECTRICITY. By Robert A. Millikan, Francis B. Crocker and John Mills. American Technical Society, Chicago, Ill. Cloth; 318 pages, 5½x8½ in.; 323 illustrations.

ELECTRICAL MEASUREMENTS. By O. J. Bushnell and A. G. Turnbull. American Technical Society, Chicago, Ill. Cloth; 165 pages, 5½x8½ in.; 139 illustrations.

MATERIALS OF MACHINES. By Albert W. Smith. John Wiley & Sons, Inc., New York. Second edition. Cloth; 215 pages, 4¾x7½ in.; 36 illustrations.

MECHANISM OF STEAM ENGINES. By Walter H. James and Myron W. Dole. John Wiley & Sons, Inc., New York. 165 pages, 5¾x9¼ in.; 183 illustrations.

POWER

Vol. 41 NEW YORK, JANUARY 19, 1915 No. 3

A New Year Letter

Written by the supervising engineer of a public utility-company in the Middle West to engineers of different power plants under his direction.

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Dear Sir—With the beginning of the new year it might be well for all of us to investigate every point about our power plant with a view to getting higher economy, if possible, in our future operation and maintenance. Below are a few questions we should ask ourselves, answering them in our own minds, not allowing the matter to drop until we are satisfied everything possible has been done and a report made out stating why certain results cannot be attained:

Are our boilers clean; is the brickwork in good condition, and are all cracks and unnecessary openings airtight?

Is the feed-water heater clean and working efficiently, and is the water as hot as possible?

In water-tube boilers, do we know that the baffling is tight and that the gases are not short-circuited directly to the stack?

Are we sure all blowoff valves are tight and that we are not blowing down too much?

Are our dampers working, and do we use them instead of closing the front doors on hand-fired boilers, allowing cold air to filter through the brickwork, etc., or, on stokers, allowing the fires to burn off the back of the grate?

Are we carrying a steady maximum steam pressure?

Are all our grates, gages, flue cleaners and other boiler auxiliaries in perfect condition?

Have the soot and ashes been cleaned out of the bases of the stacks?

Do we know that the breeching is not partially stopped up with soot?

Do we know that our draft is the maximum possible under the existing conditions?

Are we using the minimum amount of labor to properly perform the work in both the engine room and the boiler room?

Are our engines operating as economically as possible under their present conditions?

Do the pistons leak?

Do the valves leak, and are they properly set?

Is there undue drop of pressure between the boilers and the engines?

Is the steam reasonably dry?

Is the back-pressure on the exhaust a minimum?

If we are using superheaters, do we know that we have the maximum superheat?

If not, are the superheaters stopped up or dirty?

Are all steam traps in good condition, or are valve seats cut, floats collapsed or other parts defective?

Are all exposed heating surfaces properly covered?

Do we know that all valves on steam lines and all drain valves are tight?

Are all drains from oil separators, heaters, piping, etc., clear?

In plants running condensing, are we using the proper auxiliaries to keep our feed-water temperature a maximum and our motor-driven auxiliaries operating at maximum efficiency due to low temperature of the condensing water?

Are we trying to get a maximum hotwell temperature by controlling the amount of condensing water to the condensers?

Have we the maximum vacuum possible with the present temperatures, barometer and load?

Do we keep a maximum load factor on the apparatus in use?

Do we try to keep down the cost of supplies, such as lamps, oil and waste?

Do we know that our apparatus and our station light and power wiring are in safe condition?

Have we fire extinguishers on hand, and any fire hose we may have properly connected?

Have we taken all precautions to prevent accidents by protecting all openings by railings, inspecting all ladders to see that they are safe, looking after all weights or other heavy parts that may be suspended from above, and seeing to it that all pulley blocks, tackle chains and other tools are in perfect order; that there are no oily or slippery places in or around buildings; that piping or any part of apparatus in use is not showing signs of strain; that proper guards are placed around wiring, switchboards and high-tension apparatus, and that danger signs are placed where necessary?

Have we prepared for extreme weather conditions in the way of ice, floods, lightning, etc.?

Have we taken care of the effects of high winds and rains on our stacks, windows, roofs, etc.?

The whole thought of this letter is to bring out any suggestions or ideas you can put forward to improve our economy and service. If you will put in writing anything of this nature we will be glad to make every effort to get the matter attended to.

[*Written by F. W. Laas, Cedar Rapids, Ia.*]

Baltimore Sewage-Pumping Plant

By Warren O. Rogers

SYNOPSIS—This sewage-pumping plant has three 400-hp., 27,500,000-gal. pumping engines and three 260-hp. water-tube boilers. Sewage is pumped against a head of 72 ft. through 42-in. discharge pipes. Drainage water is used in the condensers of the pumping engines and is handled by engine-driven centrifugal pumps. Sewage from the Back River disposal plant is utilized to operate two 150-hp. waterwheels, each driving a 110-kw. alternating-current generator the electrical output of which is used for lighting and motor circuits at the disposal plant.

What is regarded by engineers as the most scientific system in the world for handling sewage is the twenty-one-million-dollar sewage system now under construction at Baltimore, Md. Prior to the great fire in 1904, the city, with a population of nearly 600,000, was without a sewage system, depending on cesspools and private sewers.

Owing to the contamination by sewage of the waters of the Chesapeake Bay and the injury done the oyster industry, the legislature passed laws requiring a sewerage system and the purification of the sewage before discharging into the bay. A sewerage commission was appointed, with Calvin W. Hendrick as chief engineer, under whose direction this system was constructed and is now nearing completion.

By a series of intercepting sewers, about two-thirds of the city's sewage is carried to Back River by gravity; the rest is intercepted along the river and harbor front. Upon reaching the new pumping station near the center of the city, it is pumped against a head of 72 ft. through 42-in. iron mains for about a mile, from which point it flows by gravity to the disposal plant at Back River, some six miles east of the city.

Pumping Plant

The pumping station (Fig. 1) is constructed of brick and stone on a concrete foundation. Below the main floor the walls are of granite, and above they are of light-brown brick with terra cotta moldings. The roof is of slate, supported by steel trusses carried by steel columns built into the walls.

The building is fireproof, has an outside dimension of 188 ft. by 156 ft. 7 in., and is 59 ft. high from the ground to the top of the walls. The engine room is 180 ft. long, 51 ft. wide and 68 ft. high from the basement floor to the tie beams of the trusses. It is lined with enameled brick for 23 ft. above the basement floor.

At present there are three triple-expansion, crank and flywheel, condensing pumping engines (Fig. 2) having 22, 42 and 62 by 60-in. steam cylinders. These units run at 20 r.p.m., each having at this speed a capacity of 27,500,000 gal. of sewage every 24 hr., or a total of 82,500,000. The horsepower of the engine is 400 at normal speed, with 175 lb. steam pressure, and operating with a 28-in. vacuum. The first receiver pressure is 32 lb. and the second receiver has a pressure of 2 lb. gage. These pumping engines rest on concrete foundations separated from the building so as to absorb any vibration.

The boiler room is separated from the engine room by a screen chamber below the main floor level and a machine shop and storeroom on the main floor level. The boiler room is 94 ft. long by 50 ft. wide, with space for five 260-hp. water-tube boilers set separately; at present there are but three 260-hp. boilers (Fig. 3). Each has two steam drums 23 ft. 3⅝ in. long and 36 in. diameter, made of $\frac{7}{16}$-in. plate. The tubes are 18 ft. long and 4 in. diameter. The heating surface of the drums is 193 sq.ft. and that of the tubes 2473, a total of 2666 sq.ft.

Two of these boilers are estimated as having sufficient capacity to supply steam for the three pumps. One boiler only is under pressure now, and it supplies steam for the pump that handles the sewage at the present time. The spare boiler is held to take care of fluctuations in the sewage. Each boiler is capable of supplying steam for one pumping engine and all auxiliary machinery.

The boilers are hand fired and have a grate area to heating surface of 1 to 44.4. The furnace gases pass to an economizer above the boilers having 1550 sq.ft. of heating surface; it heats the water from the main pump feed-water heater from about 90 to 160 deg.

All the boilers are connected to a single brick chimney 200 ft. high above the boiler-room floor; it has an inside diameter of 10 ft. at the top. It is lined with firebrick for half its height and rests on a concrete foundation. The draft is controlled by a damper regulator which operates a main damper between the boiler and the stack. Each boiler has a connection to a CO_2 recorder. One boiler is equipped with a superheater.

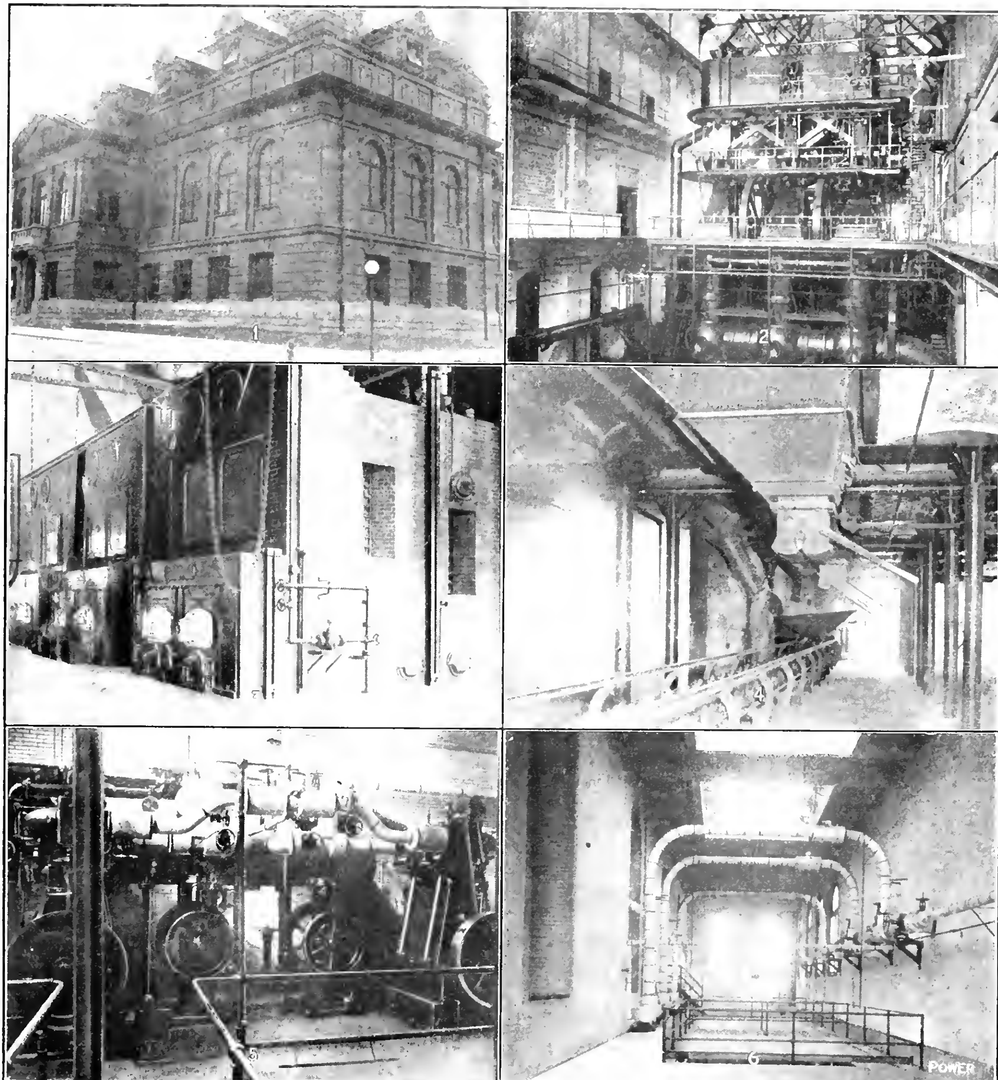
The boiler feed water is metered, each boiler having a separate meter and a differential draft gage. Feed water is handled by either of two 6 and 3¼ by 6-in. pot-valve outside packed duplex pumps back of the boilers. Coal is delivered to the plant in barges and unloaded by a grab bucket into a hopper which delivers the coal to a bucket conveyor, and then into any one of the five 200-ton bins above the boilers. The conveyor also carries the ashes from the basement to an ash bunker at the top of the boiler room, where they are loaded into wagons for removal. Fig. 4 shows the bucket conveyor in the basement.

At one end of the pump room are two 40-hp. centrifugal pumps driven by 7 and 14 by 8-in. compound condensing engines. Each pump has a capacity of 3000 gal. per min. and draws water from underdrains below the interceptors, and discharges either through the condensers of the main pumping engines or to the harbor direct. These engines (Fig. 5) each drive an air pump by a noiseless chain drive. At the same end of the building there is a 35-kw. 7 and 13 by 8-in. compound engine-driven generator set delivering current at 250 volts, at 300 r.p.m., for station lighting and motor circuits. There is also a smaller generator driven by an 8x7-in. vertical engine, and a small motor-driven air compressor, used to supply air for operating the exhaust valves on the low-pressure cylinder, at from 28 to 30 lb. pressure.

Screen Chamber

In the basement, between the pump and boiler rooms, is the screen chamber, and below its main floor is a reservoir into which the sewage is discharged from the interceptors and then drawn by the pumps. All sewage is screened twice, first through a set of movable screens at the entrance to the screen chamber and then through a fixed screen over the suction pipes of the pumps. The

Above the screen chamber, level with the pump-room floor, are toilets for the engineer and firemen, a machine shop large enough to do ordinary repairs, and a storeroom. Above these is a header room (Fig. 6). The steam piping between the boilers and pumping engines



Views of the Baltimore Pumping Station

Fig. 1. Exterior of the Baltimore sewage-pumping station. Fig. 2. Pump room, containing three 27,500,000-gal. capacity pumping engines. Fig. 3. Three 260-hp. water-tube boilers. Fig. 4. Coal and ash bucket conveyor. Fig. 5. Engine-driven centrifugal circulating pumps. Fig. 6. Header room between boiler and pump rooms

movable screens catch the coarser materials, which are hoisted out, the water with which they are saturated is removed in a steam press, and the screenings are then burned in a special furnace in the boiler-room basement.

is so arranged that no single accident can put more than one boiler or pumping unit out of service. On the boiler-room side of the header room is an 8-in. main header which reduces to 4 in. at the ends. This header is held in place by brackets secured to the side wall about 12 ft. above the floor. On the opposite side of the room, near the floor, a duplicate 8-in. header is piped to the opposite header by three 5-in. long-radius bent pipes. The pipe connections between the second header and the pumping engines are 5 in. in diameter. A duplicate set of auxiliary pipes runs from the headers to the auxiliary units in the pump-room basement. Both headers are dripped to a separate drip line and the water of condensation returned to the boilers. The plant is operated by F. H. Cronin, chief engineer.

Sewage from the pumping plant is discharged into the main sewer at a point where it will flow by gravity to the disposal plant at Back River. Here there are three hydrolytic tanks, three sludge-digesting tanks and 18 acre of broken-stone sprinkler filters, together with two settling basins. There are in process of construction 28 Imhoff tank units, 16 sludge-digesting tank units, with accompanying sludge beds, and 12 additional acres of broken-stone sprinkling filters.

As the sprinklers are 15 ft. below the hydrolytic tanks, a head is obtained sufficient to spray the sewage over the stone beds through nozzles spaced 15 ft. apart. The hydraulic head is controlled by butterfly valves which cause the sprays to rise and fall, varying from close to the nozzles out to the limit of 15 ft., thus utilizing uniformly all of the surface of the stone bed as the nozzles throw a square spray.

All spray falls on the beds and trickles down through 8½ ft. of broken stone, coating the stone with a gelatin-like film in which certain bacteria multiply by millions and attack and kill the injurious bacteria in the sewage. When the sewage reaches the bottom of the filtering beds it is practically pure. It then finds its way to a central passage under the beds and is delivered to the settling chambers, requiring three hours for its passage. The sewage then drops 18 ft. through either of the two 150-hp. waterwheels in the power house.

The power thus obtained is used to operate two 110-kw., 60-cycle, three-phase, 2300-volt alternating-current generators (Fig. 7), at 276 r.p.m. The two 7½-kw., 125-volt exciters are each driven by a noiseless chain belt at 1000 r.p.m.; the speed of the generators is regulated by two belt-operated hydraulic governors. The output of these two generators is utilized for illuminating the disposal plant and for operating small motors. To insure against interruption of service, an 85-hp. gas engine is coupled by a clutch to one of the generators so that if there is not enough water to operate the unit the engine can supply the power. It runs at 276 r.p.m. and has three 10½x16-in. cylinders.

At one side of the room is a motor-driven centrifugal pump with a capacity of 600 gal. per min. against a head of 157 ft., at 1750 r.p.m. This pump forces water into a tank and is used for washing out the hydrolytic tanks and for general flushing purposes.

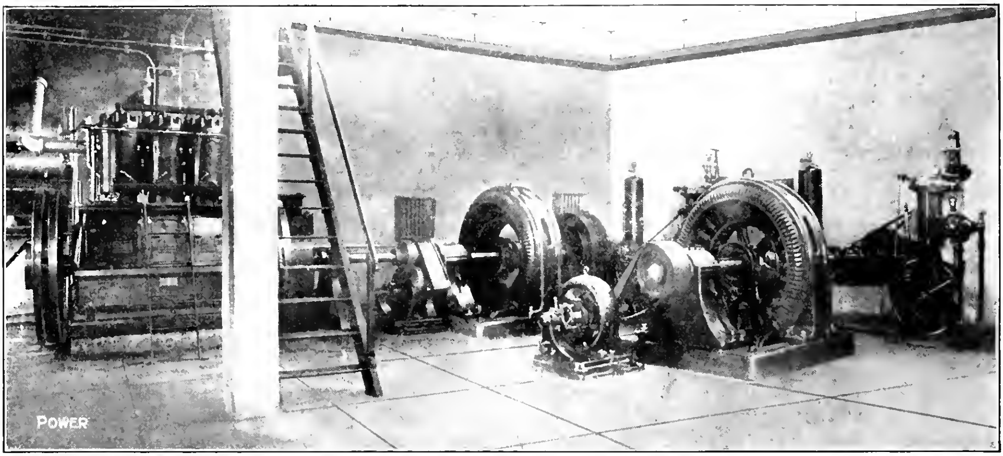


Fig. 7. Generating Plant at the Back River Disposal Plant

PRINCIPAL EQUIPMENT OF THE BALTIMORE, MD., SEWAGE PUMPING AND DISPOSAL LIGHTING PLANTS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Pumping engines	Triple expansion	22x42x62x60 in	Pumping sewage	20 r.p.m., 27,500,000 gal. capacity, 72 ft. head	Bethlehem Steel Co
3	Boilers	Water tube	260 h.p.	Steam generators	165 lb. steam	Babcock & Wilcox Co.
1	Economizer	Green	1550 sq ft ht. surface	Heating feed water	Water raised to 160 deg	Green Fuel Economizer Co.
3	Gages.	Draft.		Furnace draft.		Lewis M. Ellison
1	Regulator	Damper		Draft control	Automatic	Locke Regulator Co.
1	Recorder	Uehling CO_2		Determining per cent. CO_2		Uehling Sales Co.
2	Pumps	Duplex	6x3¾x6 in	Boiler feeders	165 lb. steam	Epping Carpenter Co.
1	Superheater	Foster		Superheating steam		Power Specialty Co
2	Pumps	Centrifugal	12 in	Drainage	Engine driven	Lawrence Machine Co.
2	Engines.	Vertical compound	7x14x8 in	Driving drainage pumps	Steam 165 lb. ...	Lawrence Machine Co
2	Pumps	Edwards air		On condensers...	Chain belt driven	Wheeler Condenser & Mfg. Co.
1	Engine.	Compound	7x13x8 in	Driving 35-kw. generator	165 lb. steam, 300 r.p.m	Trenton Engine Co.
1	Generator	Direct current	35 kw.	Engine driven...	300 r.p.m., 250 volt	Fort Wayne Elec. Works
1	Engine.	Single	8x7 in.	Driving small generator	165 lb. steam, 400 r.p.m	Trenton Engine Co
1	Generator	Direct current	15 kw.	Engine driven...	400 r.p.m., 250 volt	Fort Wayne Elec. Works
1	Motor.....	Direct current	2 hp	Driving compressor.	1350 r.p.m., 220 volts..	Allis-Chalmers Co.
1	Compressor	Christensen		Compressing air.	Motor driven	Christensen Engineering Co.
2	Turbines..	Water.	150 hp	Driving generators	18 ft. head, 276 r.p.m.	S. Morgan Smith Co
2	Generators..	Alt. current	110 kw	Power and lighting circuits	276 r.p.m., 3 phase, 60 cycle, 2300 volts	Fort Wayne Elec. Works
2	Generators	Direct current	7½ kw	Exciters.	1000 r.p.m., chain drive, 125 volts	Fort Wayne Elec. Works
1	Engine.	Vertical, gas	85 hp. ...	Driving a. c. generators	276 r.p.m.	National Meter Co.

The Hot-Bulb Oil Engine

By Edwin Lundgren

SYNOPSIS—Description of the important details and points which the designer has to consider, with data gained from practical experience.

The oil engine with hot-bulb ignition is a type that has been developed widely during the past ten years, and which has gained a large field of application in Europe, particularly for marine and for agricultural purposes. Of course, the main condition for commercial success is rational management and good shop methods, but the design of the product is just as important. The paramount requirement is a reliable engine, as nearly foolproof as possible, and of simple construction. The two-stroke-cycle type appears to have proved simpler and more economical than the four-stroke-cycle engine with hot-bulb ignition; therefore, this type will be selected for discussion.

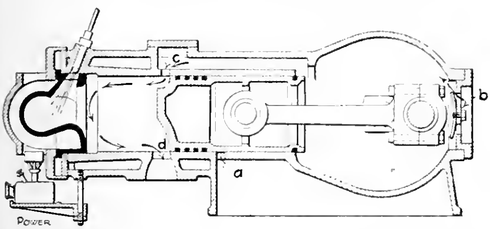


Fig. 1. Typical Two-Stroke-Cycle Hot-Bulb Engine

Reference to Fig. 1 will make clear the principle of this engine. Air is sucked into the crank chamber by the piston, either through ports *a* in the cylinder wall or through a simple air valve *b*; it is then compressed in the crank chamber and led through a bypass and ports *c* into the cylinder, where it is deflected by the piston and expels the exhaust gases through the ports *d*. The cylinder is now filled with air; not pure air, of course, as the quantity admitted is not large enough to scavenge perfectly and as the nature of the process makes perfect cleaning of the cylinder impossible. This mixture of pure air and burnt gases is compressed by the piston on its return stroke, and at 50 to 85 per cent. of its travel, the fuel—kerosene, fuel oil or crude oil—is injected through a fine spray nozzle directly into the heated vaporizer or hot-bulb head. At about dead-center spontaneous ignition takes place, an explosion and combustion follow, and the piston is driven forward on its working stroke until it uncovers ports *d* and then *c*, whereupon the cycle is repeated.

The typical indicator diagram of Fig. 2 illustrates the process within the cylinder, showing the compression to be fairly high, varying in different designs from 90 to 110 lb. per sq.in. The explosion pressure may reach 300 to 350 lb. per sq.in.

Considering the relative merits of three-port and two-port engines, it may seem at first that the three-port is the simpler and better, but the reverse is true, as the two-port engine requires a simpler casting. Also, for lubricating, it is better to avoid the third port, and the two-port engine gives a little more power. For smaller sizes it is advisable to cast the cylinder and frame in one piece, and the saving in machinery will offset the higher cost of casting. One of the most important parts is the cylinder head and vaporizer or bulb. Figs. 3 to 6 show different types which have been used successfully. The clearance volume is $\frac{1}{1.5}$ to $\frac{1}{5.5}$ of the stroke volume according to the compression desired. The walls of the vaporizer, which are usually cast iron but sometimes cast steel, have to be made fairly thin, otherwise too much time will be required to heat it for starting.

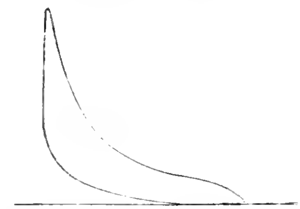


Fig. 2. Indicator Diagram from Two-Stroke-Cycle Hot-Bulb Engine

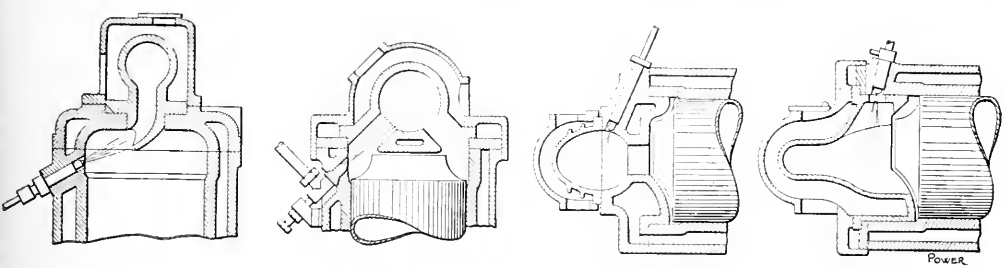


Fig. 3 Fig. 4 Fig. 5 Fig. 6

Different Arrangements of Hot-Bulb Ignition

Against the walls of this heated vaporizer the fuel is sprayed in a fine mist. The proper formation of this spray, however, requires experience. If it is too fine, preignition will occur, whereas if it is too coarse, combustion will not be good, and high fuel consumption will result.

A good nozzle construction is shown in Fig. 7. After passing through one or two check valves the oil is led through the spiral grooves and the fine hole at the point of the nozzle, the size of the hole and the depth of the grooves exercising a decided influence upon the formation of the spray.

Of course, the action of the fuel pump is also important. It must have a quick, short stroke, and as the fuel for each revolution has to be forced through a fine hole within a fraction of a second, the pressure must be very high; the writer has measured it to 800 lb.

A typical construction of fuel pump and governor is shown in Fig. 8, the design being simple and self-explanatory. The steel plunger is ground in the brass body of the pump. Sometimes a packing is not provided, although it is to be preferred. If used, it should not be tightened enough to hamper the return stroke of the plunger, which is produced by the spiral spring. The stroke can be varied by shifting the block *a*, and the pump

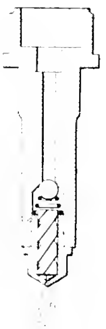


Fig. 7. Fuel Nozzle

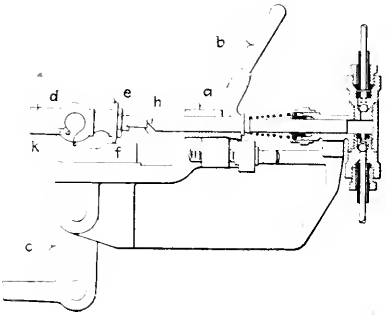


Fig. 8. Fuel Pump and Governor

can also be actuated by hand through the lever *b*, which is necessary when starting.

The simplest governor is the "hit-and-miss" type and for most purposes it is sufficient. In Fig. 8, the lever *c* receives its motion from a cam or an eccentric. To it is attached a lever *d*, which carries a square fiber disk *e*, and by means of a spring *k* is pressed down on block *f*. Usually the disk *e* just slides back and forth on the block, but if the speed increases, the lever with the fiber disk, due to inertia, jumps too high when it leaves the little incline shown, and thus its edge *g* misses the edge *h* of the push-rod. In this manner the speed can be kept within narrow limits when changing from full load to no load, and it can be adjusted by changing the tension of the spring *k* or by shifting the block *f*.

The speed also can be controlled by a flywheel governor, which changes the stroke of the fuel pump or keeps the suction valve open during part of the pressure stroke. As an alternative, an ordinary centrifugal governor may be employed which acts in a similar manner, or which shifts a cam that in turn gives the pump a different stroke.

A weak point with many engines of this type is the injection of water into the cylinder. This is necessary for heavy loads as otherwise preignitions will occur. On the other hand, water should not be admitted when the engine is running idle or at light loads, for it will misfire and possibly shut down. The water retards combustion and effects cooling. The effect of water injection is shown in the indicator diagram, Fig. 9, where purposely a little too much water was admitted. Usually, the water

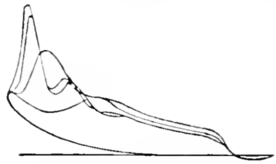


Fig. 9. Showing Effect of Water Injection

is admitted in a rather crude way, through a needle valve into the bypass, from which it enters the cylinder with the air. In this case continuous attention has to be paid to the needle valve to regulate the amount of water. If the load is fairly steady, no attention is required, but with a varying load it is inconvenient. Therefore, in several designs the water is injected by a small pump under the influence of the governor, thus giving more or less water to suit the load.

With a view to eliminating the necessity for water injection, the writer once built an engine having a flywheel governor that turned the pump-actuating eccentric so that with light loads the injection took place at the usual time, but at heavy loads so late that no preignition could occur. The engine worked all right, but experience has shown that even here water injection proved advantageous, as it increased the power.

Of prime importance also are the dimensions of the ports for the air inlet and the exhaust, which depend largely on the size and speed of the engine; the greater the speed, the larger the ports, although in larger engines the ports can be made relatively smaller. On an average, the length of the exhaust ports is 20 to 22 per cent. of the stroke, and that of the inlet ports 9 to 13 per cent., while they occupy about 90 deg. on the circumference. The exhaust ports should be uncovered so early that the pressure in the cylinder is almost nil when the

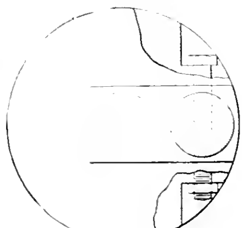


Fig. 10

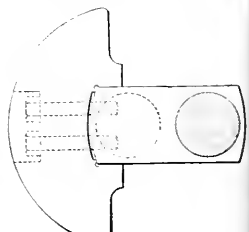


Fig. 11

Wrong and Proper Designs for Counterweights

inlet ports open, for only in that case can effective scavenging be obtained.

The pressure of the scavenging air is not high, about 4 to 5 lb. per sq.in., but it is enough to blow the air and oil out of the crank case through every possible opening, particularly around the shaft. In small engines this does not amount to much, for the bearing is usually a straight cylindrical bushing, and if sufficiently oiled, does not let any air escape. Sometimes a steel disk is placed on the shaft, the idea being that the side of this disk, in contact with the bearing, will keep tight enough even if the bearing wears down a little. In other cases disks are employed which do not rotate but which are pressed by springs against the crankshaft, making a good joint. In still another arrangement a cast-iron ring is sprung into the bearing.

In order to make the pressure in the crank case as high as possible and render the crank case efficient as an air pump, the clearance must be kept as small as possible. A long stroke is therefore not advisable. The importance of the clearance is, however, often overrated as it does not pay to make a counterweight such as that in Fig. 10; Fig. 11 is a better design. The writer once tried several engines with and without counterweights and marked difference in power was not noticeable.

In a horizontal engine the counterweight is necessary, for otherwise too strong vibrations will occur. While a counterweight like that in Fig. 11 is best, it is cheaper

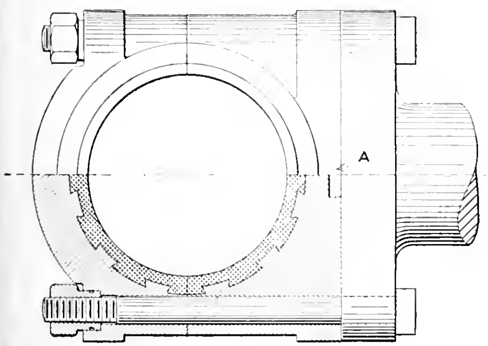


FIG. 12. CONNECTING-ROD END

to cast one in the flywheel. However, it is not to be forgotten that such a weight revolving at high speed will cause additional stress on the main shaft. The main parts of the crank mechanism offer no extraordinary features, and are usually computed, assuming an explosion pressure of 300 lb. per sq.in. For determining bearing surfaces a lower value can be used—about 250 lb.

The connecting-rod should be so designed that an adjustment of its length can easily be made, the marine head, as shown in Fig. 12, being recommended. The head should be as small as possible, so as not to make the crank chamber too large. Often the dimension *A*, Fig. 12, is too small, for it must be remembered that sometimes rather violent knocks occur which are hard on the material. Ample clearance (3/8 to 1/2 in.) should be provided where rough cast-iron surfaces are concerned.

For lubricating the main bearings ring oilers are preferable. A system of force feed is really the best, but it is more expensive and requires more attention. With forced feed the castings are simpler than for ring oiling. Although the performance of this type of engine is not as good as the high-compression or Diesel type, the high economy of the latter is offset by the many complicated parts, which make the small sizes prohibitively expensive. For these small sizes (2 to 50 hp.) the type described has proved reliable and economical.

Safety-Valve Specifications

BY A. B. CARHART

The specifications concerning safety valves in the proposed boiler code, as recently revised by the committee of the American Society of Mechanical Engineers, are of special importance because they express briefly and clearly all of the details concerning safety valves that were discussed and unanimously agreed upon at a conference held in Boston a few weeks ago, at which nearly all the safety-valve manufacturers of this country were represented. These specifications, therefore, may be regarded as representing the best modern practice, for they embody the combined experience and judgment of those who have had the best opportunities for the study of the subject; and as nothing at that conference was adopted without unanimous assent, the provisions must be regarded as safely conservative and proper.

The paragraphs concerning common lever valves are of little present importance, in view of the recommendation that all other than modern pop safety valves should be replaced as soon as possible.

An item of special interest in paragraph 19 is the requirement that each boiler carrying a pressure over 15 lb. and requiring a valve larger than 3 in. must have at least two safety valves. This does not mean duplicates, but that the total requirements shall be divided into smaller units. It insures greater safety and better operation of the valves and boiler. It is not likely that both valves would ever be inoperative at the same time. Safety valves are calculated to discharge the maximum steaming capacity of the boiler under extreme conditions, and each time a single large valve opens it will discharge steam at a rate much greater than generated under normal conditions. This sudden discharge is wasteful, and the pressure will drop more than necessary before closure. To avoid this, safety valves are often adjusted to blow down only one or two pounds and operate with unreasonable violence, causing destructive hammering in the valve and a considerable shock to the boiler when the large outflow of steam is suddenly checked, which in effect produces a miniature explosion every time the valve opens.

Under ordinary conditions a small valve, operating very gently, would afford adequate relief and it requires much less attention than a larger one. The second and third valves would not open unless the pressure should continue to rise, but would be in reserve as emergency protection two or three times greater than required under normal conditions.

Under paragraph 20, additional safety-valve protection is required on low-pressure boilers, because the rate of flow through the same orifice is less at the lower pressure.

In paragraph 21, an entirely new maximum evaporation calculation has been adopted. Modern conditions, with stokers and forced draft, show fuel consumption much greater for a given grate area than formerly, therefore the new formula and table proposed by the A. S. M. E. seem much more logical.

Paragraph 24 requires that valves shall be of the direct spring-loaded "pop" type. Prior to 1875, all valves, and since then some valves, have been made that are spring loaded, but do not have the pop feature.

For low steam pressure such valves serve fairly well, but their chief defect is that they open only slightly when the steam pressure reaches the set limit, and do not lift higher as the pressure increases except by some special device. This consists of an addition to the disk excluded from the pressure of the steam when the valve is closed, but when the valve opens, the steam acts upon the additional area also and causes the valve disk to suddenly rise more than it would by the pressure upon the original area only.

The table on page 36, paragraph 21, fixes the normal steam discharge to be expected of each commercial size of safety valve at the several pressures given. It is required in paragraph 22 that all valves must show lifts and discharges at least equal to the values given in the table, when the blowdown in boiler pressure is regulated to the amounts specified in paragraph 30. It is further provided that the discharge rating of a safety valve, for the purposes of calculating the number and size of valves necessary for a boiler, shall not be greater than the values given in the table. This embodies the unanimous agreement of all manufacturers at their recent conference, following a long discussion of this special topic.

The requirement in paragraph 27 that safety valves must be attached directly to the boiler without intervening pipe or fitting or internal dry pipe, and upon a separate outlet independent of any other steam connection, has perhaps aroused more comment and criticism than any other in these specifications; yet in the judgment of those having the greatest experience and special knowledge of the subject, this is probably the most important requirement. All of the valve manufacturers were unanimously for this provision in its present form.

The provision in paragraph 25 that the several valves on the boiler should be set to open at pressures at least 3 lb. or 5 lb. apart seems proper. To set several valves on the boiler to open at nearly the same pressure is a mistake, because ordinarily the amount of steam to be discharged is much less than any one of the valves alone could properly take care of. Two or three valves opening intermittently will involve much damage to themselves and harm to the boiler.

Paragraph 30, as to the proper amount of blowdown in pressure for which the valves should be adjusted to close, is the result of the experience of all of the safety-valve manufacturers. Close regulation is harmful, generally resulting in sharp and violent action of the valve in opening and closing, shortening its useful life and unduly straining the boiler.

The purpose of the lifting gear specified in paragraph 31 is simply to afford some means of insuring that the valve disk is free and that its action is not interfered with by deposits of boiler scale or lime in the valve guides.

Paragraph 36 specifies that safety-valve springs shall withstand a cold compression test without showing any permanent set. This is to avoid dangerous consequences if the spring is screwed down to hold the valve closed during a boiler test. That such practice is entirely wrong is recognized in paragraph 10, which specifies that a test clamp or gage shall be used to hold the valve disk upon its seat during such a test.

There is also a provision that a spring shall not be used for any pressure more than 10 per cent. above or below the working pressure for which it was designed. That valves will not operate properly and will not give normal lift or blowdown when the springs are either too weak or too stiff is not always recognized.

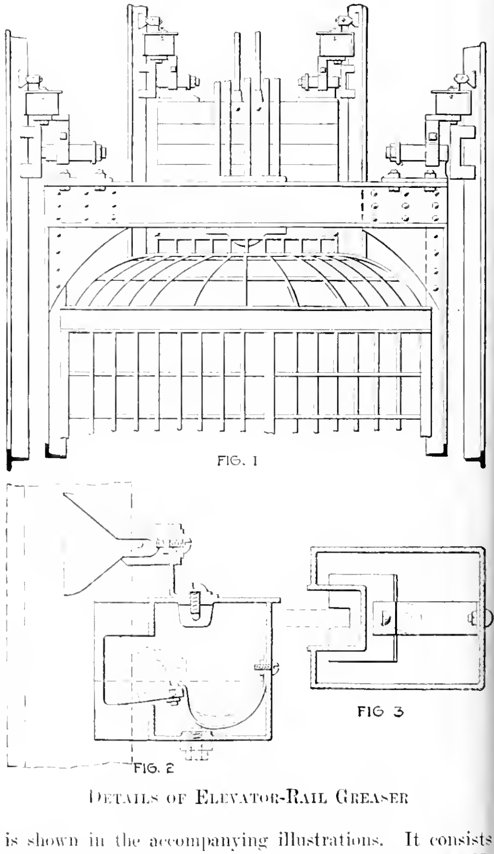
Paragraph 39 provides that at least one safety valve shall be connected near the outlet of a superheater to insure a circulation of steam through the superheater, to protect it from harmful rise of temperature in case the normal demand for steam is suspended for any reason. Valves smaller than the 3-in. size are recommended for this service, as they are more easily maintained and kept tight. Paragraph 41 provides for standard flanges for each valve size.

The following joint letter was forwarded to the Council of the A. S. M. E., on Nov. 11, 1914:

We, the following safety-valve manufacturers, have carefully examined the third edition of the preliminary report of the Special Committee on the Construction of Steam Boilers, with particular reference to the specifications applying to pop safety valves, and are all agreed that these embody just what was unanimously accepted by the valve manufacturers who were in conference on Oct. 2, 1914. We therefore respectfully urge that your body accept and approve of same without modification, aside from such typographical errors as may be found therein.

Elevator-Rail Greaser

A device which will lubricate continuously and automatically the guide rails of the car and counterweight of an elevator has recently been perfected. The apparatus



Details of Elevator-Rail Greaser

is shown in the accompanying illustrations. It consists primarily of a box to hold the grease, which has a U-shaped recess so that it may straddle the web of the rail.

Through an opening in this recess a double-ply leather wiper projects. It is notched to fit the rail and, being attached to the wall of the box by a flexible spring, is free to move vertically. When the car is going up, the leather wiper is in the position shown by the full lines in Fig. 2. The dotted lines show its position for a downward movement of the car. The spring also tends to push the leather forward against the rail.

The box is filled with an even mixture of grease and graphite of the proper consistency to flow to the rail when it is agitated by the movement of the leather and spring. The greaser is attached to the top beam of the car or counterweight (Fig. 1). The feed of the grease is varied by moving the box toward or away from the rail. To remove any excess grease from the rail and drop it back onto the leather a double-bladed scraper straddling the rail is mounted on top of the box. The blades are adjustable for varying widths of guide, and in or out adjustment is permissible as they are secured to the top of the box by a screw passing through a slot.

When supplied, the box is filled with grease. At the end of six months the level of the grease is usually lowered to a point from which it cannot reach the rail. About half a pound of grease is needed to refill the box, and it is claimed that the device is then ready for another six months' service. The cover may be removed by loosening three screws which pass through the casing of the box into lugs projecting down from the cover. With this arrangement it is not necessary to remove the screws entirely and thus run the risk of dropping them into the elevator well.

Results of tests conducted on electric elevators equipped with these rail greasers show a reduction in starting torque of from 10 to 25 per cent. over dry and hand-lubricated guides. Other advantages claimed are savings in shoe and rail, the elimination of jars and jerks common to an elevator guided by dry rails, noiseless operation and no dropping of oil or grease to the floor of the well. The upkeep is small as the only part subject to wear is the leather wiper. This lasts for a long period and may be renewed at a cost of a few cents. The leather is made in sizes to conform with rails having face measurements from ½ to 9 in. W. A. Garvens, 708 South Ashland Blvd., Chicago, is supplying this device.

An American Engineer in Cuba

By Frank E. Small

SYNOPSIS—Impressions of an American operating engineer sent to Cuba to put some run-down plants in safe and economical condition.

The writer hopes that none will construe the substance of the following to be a slap at all engineers in care of Cuban plants.

On going to Cuba as a trouble man one feels that the island has grown in plants faster than it has in engineers competent to care for them. There are many good men, to be sure, but many are unfit. This condition among engineers is aggravated by the unfavorable attitude of the owners or employers toward skilled labor. Cuba is of course warm, and ice and refrigeration plants become more numerous as industry grows. Some business houses have failed owing to unnecessarily high operating costs. Some of these plants are quite old, five to ten years, and the equipment has greatly deteriorated or become obsolete. To convince the owners that they should first hire a good engineer at double or triple the usual local salary, and should immediately spend money for new equipment when they are already losing money, is difficult.

The writer has found plants which, when new, produced six tons of ice for one ton of coal, although at the time of his visits they were getting but one to two tons per ton of coal. Some plants in other industries are just as bad.

At one plant a locomotive-type boiler was set in brickwork. This seemed new and led to an inquiry as to why the brick setting was used. The engineer informed us that the firebox had been patched so many times that it was deemed advisable to set the boiler in brick, putting the furnace under the back of the boiler to reduce the temperature in the firebox.

The first look into the furnace of a horizontal return-tubular boiler in this plant showed water running from around the edges of a 24x48-in. patch, the second one to be put on that crown-sheet. The writer threatened to leave if permission was not given to reduce the pressure to 80 lb. (it was 100 lb.). This seemed to create considerable laughter in the office, but when the manager was shown that that patch was carrying a load of over 115,000 lb. he began to congratulate himself on being alive.

For some reasons the boilers here had their gage-cocks removed, gage-glasses being depended upon for showing the levels. The differences between the readings of any two steam gages was so great that for safety's sake it was necessary to immediately learn the correct pressure.

A steam hose had been used to clear the tubes of soot, and although the front ends were clear enough, the back ends contained soot that had accumulated and baked on. A brush could not be pushed through the tubes.

On the way to one plant the first day, the engines could be heard pounding before the writer was within a block of the plant. Notwithstanding this condition, the engineer was as contented as could be. This plant was but four years old, although one would take it for fifteen were it not for the modern equipment.

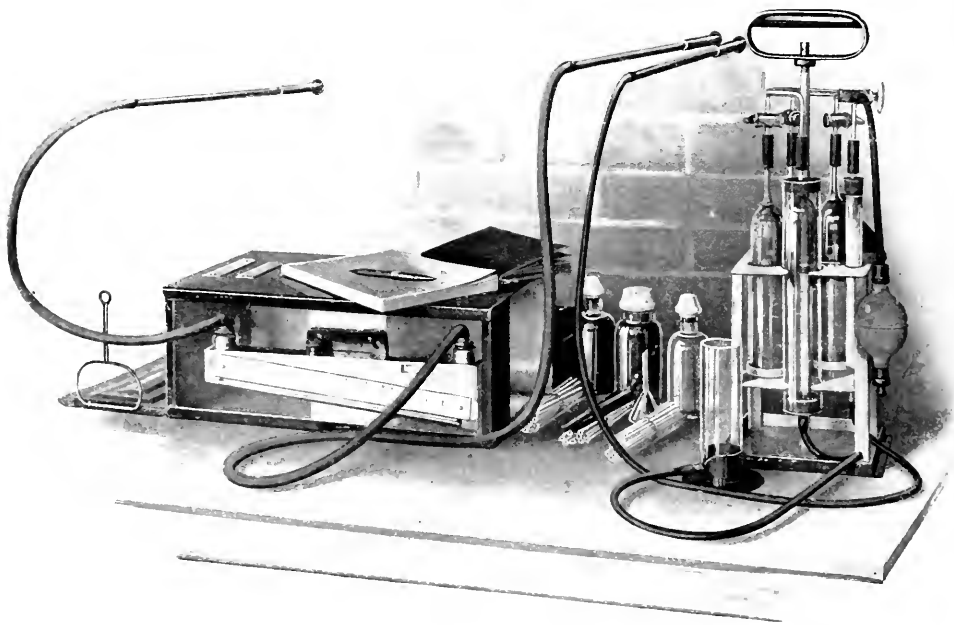
The writer's experience leads him to believe that owners should, for a time at least, receive more support from builders. Equipment is installed and operated until accepted, but in many cases it is necessary to "break in" the purchasers' engineers, and this is by no means done thoroughly. There are few competent men available, and consequently it is but a short time until the equipment is giving poor service and the builder's reputation with the local owners is injured. The builder would do well to try to get a good man to care for the plant.

At present plants here are not so much in need of men who can obtain economical results, although these must follow, as of men who can keep equipment running well.

Boiler Efficiency Kit

In checking up boiler efficiency it is essential to analyze the flue gases and take temperature readings as they leave the boiler. It is also desirable to note the draft at the fire and the drop in draft between the furnace and the damper, as these factors determine the air supply. When these data are known it is possible to calculate the combustion efficiency.

A convenient and complete kit of apparatus for obtaining the above mentioned data is being supplied by the Precision Instrument Co., Detroit, Mich. The equipment is neatly arranged in a case. The illustration shows the various devices in position for testing a boiler. The case is divided into three compartments, but by an ingenious arrangement the covers to all three compartments are locked by a small padlock within the handle of the case. A differential draft gage is contained in one compartment, the middle chamber contains an Orsat apparatus of special design and the third space a high-temperature thermometer, a special printed report pad for recording the various test data, some rubber tubing, etc.



Kit Unslung and Ready for Use

As indicated, the draft gage is arranged so that both the draft in the furnace and the drop in draft between furnace and damper may be conveniently taken. For this purpose rubber tubing of suitable length and sectional iron pipes of the fishpole variety are provided. The draft gage is graduated in hundredths of an inch. For compactness the three pipettes and the burette of the Orsat are arranged in a circle. The analyzer is graduated to read in tenths of one per cent. The necessary rubber tubing for the analyzer is furnished.

The high-temperature thermometer is encased in a brass tube to prevent breakage and is provided with sectional extension pieces so that it may be inserted through any ordinary wall of a boiler setting. In the compartment containing the thermometer there is space for storing tubing, data pads and bottles containing the chemical mixtures.

The kit is also provided with a book of instructions and manual of testing methods, a pad of standard test-report blanks, proper chemicals for absorbing CO_2, O and CO, already mixed for use, a funnel, and in short, all the necessary parts and materials required to conduct a boiler-furnace efficiency test. That all of this equipment can be kept in a small, compact case ready to be carried to the point of immediate use is an advantage.

Some Original Ideas

An operator complained of the rapidity with which the brushes of his engine-driven generator were consumed, although the load was comparatively small and there was no evidence of sparking. All brush-contact surfaces appeared to have been recently sandpapered, but he stated that they had not been touched since their installation about ten days before. It developed that the engine had been shipped from one place and the generator from another and that they had been connected on the ground.

As the commutator showed some eccentricity, a local machinist was engaged to turn the commutator in its own bearings. He had used a diamond-pointed tool, which was all right, but had also used a coarse feed and a comparatively deep cut, thereby converting the commutator surface into a milling cutter, so far as the brushes were concerned. On being recalled to finish the job, he explained that he had made that kind of surface on purpose, so as to make the brushes "bite better."

In another case, complaint was made that a machine would not generate, but by the time the inspector arrived it was generating all right. The operator stated that, as far as he knew, he had not done anything to help matters, but had let the machine run to "work in the bearings." It seems that he was particular how the machine looked and had been touching up bolt-heads and nuts with gold paint, and while doing this had concluded to give the commutator a coat, with the result that the machine would not pick up until the brush friction had removed the gold paint.

In another case a plain shunt-wound generator and an interpole generator were being operated in parallel. When the attendant wished to withdraw the interpole machine from parallel operation, he found it difficult to reduce its current to a low value. He had observed the practice of oiling commutators occasionally and at such times had noticed the current decrease on the machine. Being in the habit of applying the results of his observations, he adopted the practice of oiling the commutator of the interpole generator whenever he wished to take it out of service. The result was that the commutator absorbed so much oil that it eventually broke down.

Kingsford Double-Flow Pump

Among the line of Kingsford centrifugal pumps is that known as the double-flow type, Fig. 1, which in the illustration is motor driven. It is manufactured by the Kingsford Foundry & Machine Works, Oswego, N. Y.

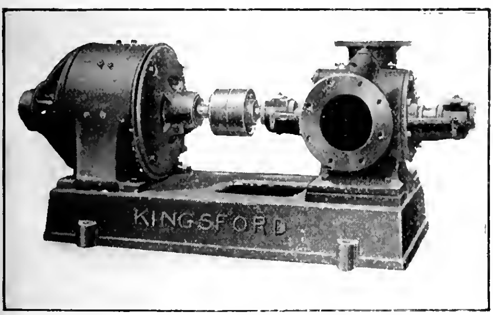


Fig. 1. Kingsford Double-Flow Pump

A sectional view of the pump is shown in Fig. 2. In this design the water-ways are liberal, the stuffing-boxes are of ample depth and the span between the oil-ring bearings is small. As the water seals are internal, the leakage is collected in the bearing buckets, and from there piped into a common waste-pipe.

The pump is so designed that with one head removed and the setscrews in the coupling loosened, the shaft and impeller may be removed from the casing without disturbing the suction or the discharge pipe connections. As the joints between the heads and shell are metal to metal, set gaskets are eliminated and alignment is insured. The impellers are made of single castings integral with the balance ring, which under ordinary conditions will wear until the impeller requires renewing. Fig. 3 shows an impeller with staggered veins; this design is used in pumps of large capacity.

Theoretically, the double-suction pump is hydraulically balanced and free from end-thrust, but in practice unequal leakage through packing fissures, inaccuracies in casting or unequal wear, supplemented by lodgment of foreign matter, all tend to disturb the theoretical balance, and the result is that end-thrust is present. In this design of pump this difficulty is overcome by automatic water balance, with which it is claimed neither wear nor foreign matter will disturb the equilibrium of the impeller. Therefore, stationary and positive thrust bearings are eliminated.

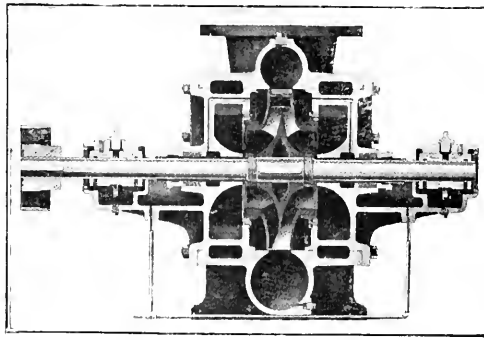


Fig. 2. Sectional View of the Kingsford Double-Flow Pump

Leakage from the pressure to the suction side of the impeller is reduced to a minimum by bronze packing rings. They are attached to the heads and in connection with rotating rings on the impeller form part of the automatic water-balance device.

Although the shells or main casings are made split horizontally, when conditions warrant, the pump is generally made with the shell of a single casting with integral sections and discharge openings. The volute surrounding the impeller permits of omitting diffusion veins for low and moderate heads. The design of this pump makes it possible to locate suction and discharge openings at various positions, as for instance a pump with a horizontal or vertical discharge is sometimes found convenient, and frequently the suction and discharge openings are desired on the same side.

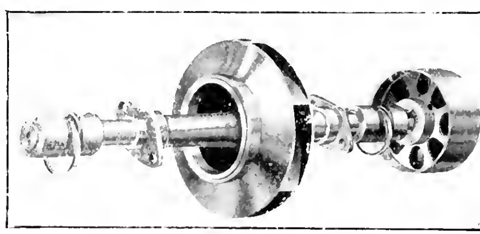


Fig. 3. Pump Shaft and Impeller

The head and bearing housings, secured to the main casting by studs, come metal to metal, and a water-tight joint is secured by a rubber cord placed in a triangular-shaped space formed in joining the heads and shell. The head forms a part of the suction chamber and guides the water into the impeller opening.

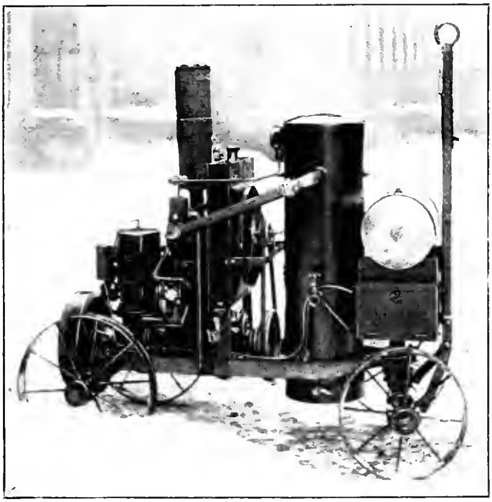
Ordinarily, the pump shaft is of machinery steel, made exceptionally large and stiff to prevent bending and to carry the impeller without vibration. When liquids which affect iron and steel are to be pumped, the shaft is covered by a sleeve of composition metal. This sleeve is provided with threaded ends and fits snugly on the shaft. It is easily removed by a special kind of wrench

In other than belt-driven pumps, a flexible coupling is used between the pumps and prime mover which allows for any slight inaccuracies in alignment. This coupling consists of cast-iron halves, one of which is fitted with steel bolts extending into corresponding holes in the other coupling half, the driving force being transmitted through the medium of rubber cushions mounted on the sleeves.

Imperial Portable Air Compressor

The small portable gasoline-engine-driven air compressor, illustrated herewith, has been developed by the Ingersoll-Rand Co., 11 Broadway, New York City.

The compressor is self-contained and is operated by a simple single-cylinder gasoline engine coupled directly to the compressor, both pistons working on the same



PORTABLE AIR COMPRESSOR

crank-shaft. The engine is of the single-acting, two-cycle type. This standard air compressor has a capacity of 45 cu.ft. per min. at a pressure of 90 lb., and is fitted with an air unloader. The engine speed is controlled by a centrifugal governor.

Cooling is provided for by a gear-driven pump and an automobile-type radiator with large tank capacity, serving both the compressor and the engine. The radiator is assisted by a large fan.

An air receiver tested to 300 lb. water pressure and fitted with a safety valve, pressure gage, the necessary piping, outlets, etc., is hung at one end of the frame and a 15-gal. capacity gasoline tank is supported on a large tool box. The outfit complete weighs 1600 lb., and is designed for hand transportation, but it can be fitted with tongue and singletrees if desired.

Efficiency Test on a Large Alternator

BY J. H. MCDOUGAL

Some time ago the writer had occasion to test a large alternator to determine its efficiency and segregate the losses. The plant was situated in the mountains, at a very inaccessible point; on which account, together with the fact that the test had to be made on short notice, it was necessary to depart from the common methods of testing.

The machine was a three-phase, 2300-volt, 60-cycle, 5500-kw. alternator direct-connected to two tangential waterwheels and operated in parallel with a number of other plants. The waterwheels were equipped with needle nozzles, the needles being operated by hand and the governing done by deflecting the nozzles. One governor controlled both nozzles.

In order to improve the accuracy of the test, two current transformers were installed of such a size that the losses of the machine, run as a motor, would give full-scale deflection on the indicating wattmeters. The regular two-wattmeter method of measuring three-phase power was used. Both nozzles were disconnected from the governor. It was also deemed advisable to install short-circuiting switches on the current transformers, as in synchronizing practically full load was sometimes thrown on the machine, which it was feared would burn up the small-capacity current transformers. As no regular short-circuiting switches were available, two blades of an old 250-volt quick-break switch were mounted on separate boards and served very well.

In making the test one nozzle, No. 1, was completely closed, and the other, No. 2, was gradually opened until the machine with its field circuit open was brought up to normal speed. After noting the position of the handwheel and the number of turns, the nozzle on this wheel was closed. Nozzle No. 1 was then opened and the machine brought up to speed and synchronized with the system. By adjusting this nozzle the load was brought to zero. Nozzle No. 2 was now opened to the point where it stood in the first part of the test and the amount of power furnished to the system was noted. It will be seen that this power plus that lost in the armature by resistance will equal the power consumed by friction and windage. This is evident, as the water that was used to deliver this power was equal to that used in overcoming friction and windage in bringing the machine up to speed. A very small error would be introduced due to neglecting the load losses, but as this would be but a fraction of one per cent., it may be neglected.

In order to determine the core loss, nozzle No. 1 was closed and No. 2 was used to bring the machine up to speed, and the field current was brought up to the normal full-load running point. The position of nozzle No. 2 was noted and it was then closed. Nozzle No. 1 was now opened and the machine brought up to speed and synchronized. After bringing the load to zero, nozzle No. 2 was opened to its position at the beginning of the core-loss test and the amount of power delivered to the system noted. This power plus the resistance loss in the armature minus the friction and windage losses gave the core loss.

To check this last reading, all water was taken off the wheels and the generator allowed to run as a motor. This reading checked very closely, although to get satisfactory readings, it was necessary to somewhat change the excitation, which of course changed the core loss to a slight extent.

In the matter of load losses, the recommendations contained in the Standardization Rules of the American Institute of Electrical Engineers were followed. One-third of the short-circuit core loss was, as an approximation and in the absence of more accurate information, assumed as the load loss.

The machine was short-circuited and brought up to speed by nozzle No. 2, and the field current increased until full-load current flowed in the armature windings. The short-circuit was then removed and nozzle No. 2 closed. The machine was synchronized by nozzle No. 1, and No. 2 was opened to the point at which it stood at the beginning of the load-loss test, and the amount of power delivered to the line was noted. The core loss for the excitation used on short-circuit was determined as for the full-load voltage. Therefore, the power shown in the load-loss test plus the armature resistance loss, minus the friction and core loss at the excitation used, divided by three, gave the core loss as nearly as it could be determined.

The armature resistance was measured with an ammeter and a low-reading voltmeter. Thus the armature resistance losses could be calculated. The field resistance was also measured and full-load excitation noted so that the resistance losses in the field could be computed. These completed the list of losses and the efficiency could therefore be computed by dividing the output by the output plus losses. The mechanical losses of the waterwheels were, of course, included in the mechanical losses obtained, but as the guarantee included these, no effort was made to segregate them.

"World's Best" Feed-Water Regulator

The "World's Best" automatic feed-water regulator, manufactured by the McDonough Automatic Regulator Co., Detroit, Mich., is of the thermostatically controlled type. The main purpose of its design is not only to secure a continuous feed, but a positive automatic control of a continuous feed to vary with the boiler load and to maintain a water level within limits best suited for constant maximum boiler capacity, efficiency and uniformity of operating conditions.

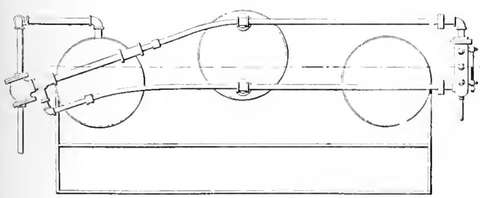


Fig. 1. Position of Regulator When Connected to a Boiler

This regulator, Fig. 2, maintains a continuous feed proportional to the evaporation and for light and uniformly varying loads a constant water level. For sudden increase in load and the resulting rapid drop in the water level, the regulator valve does not open suddenly to admit a large quantity of water into the boiler, but there is a time element in the expansion of the tubes operating the valve which uniformly increases the feed, permitting the immediate furnace heat to be used for evaporating and not for heating cold feed water.

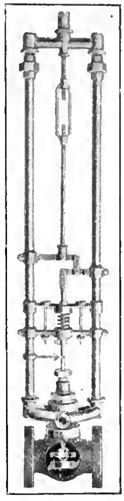


Fig. 2. Regulator

This regulator consists of a special feed valve, two headers and two expansion tubes connected in parallel through a rigid linkage to the feed-valve stem. The use of two tubes doubles the power of expansion and contraction, and the levers transmit the motion to the feed valve in a ratio of 5 to 1. A turnbuckle and pointer indicator permit of accurate adjustment of the valve, and the pointer indicator shows the position of the valve while the regulator is in operation.

The regulator is installed in an inclined position, Fig. 1, wholly supported by the feed piping with the connections made to the water column, as shown. In operation, the lower ends of the tubes are filled with water and the upper with steam. As the water falls or rises in the boiler, it correspondingly falls or rises in the regulator tubes, presenting a greater or lesser area of the tube surface to the steam, causing them to expand or contract accordingly. The inclined position of the regulator gives the greatest variation in exposed tube surface for a given variation in water level and the greatest sensitiveness to variations in load.

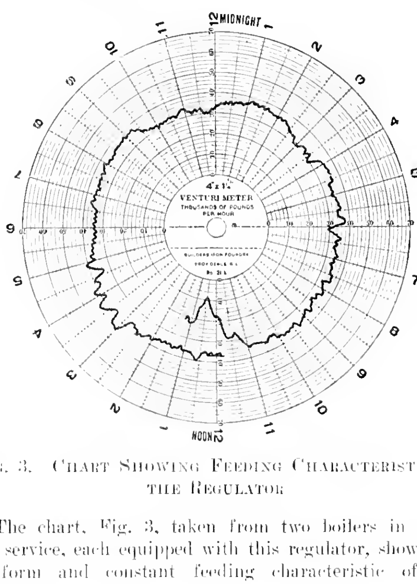


Fig. 3. Chart Showing Feeding Characteristic of the Regulator

The chart, Fig. 3, taken from two boilers in regular service, each equipped with this regulator, shows the uniform and constant feeding characteristic of the device.

Pipes for Steam Engines

By Frederick W. Salmon

SYNOPSIS—In the literature on the proper size of steam and exhaust pipes for steam engines there is little in practical shape for ready use; therefore, data of sizes of a large number of successful plants have been plotted and tables given of values obtained by plotting smooth curves representing fair averages of good practice.

There are two methods of determining pipe sizes—one is by a long and elaborate computation of pipe friction, with the use of coefficients based on a limited number of experiments; the other is what some people would call a rule-of-thumb, in which the pipe size is determined as a fraction of the cylinder diameter. The first of these is commonly based on a steam velocity in feet per minute or per second.

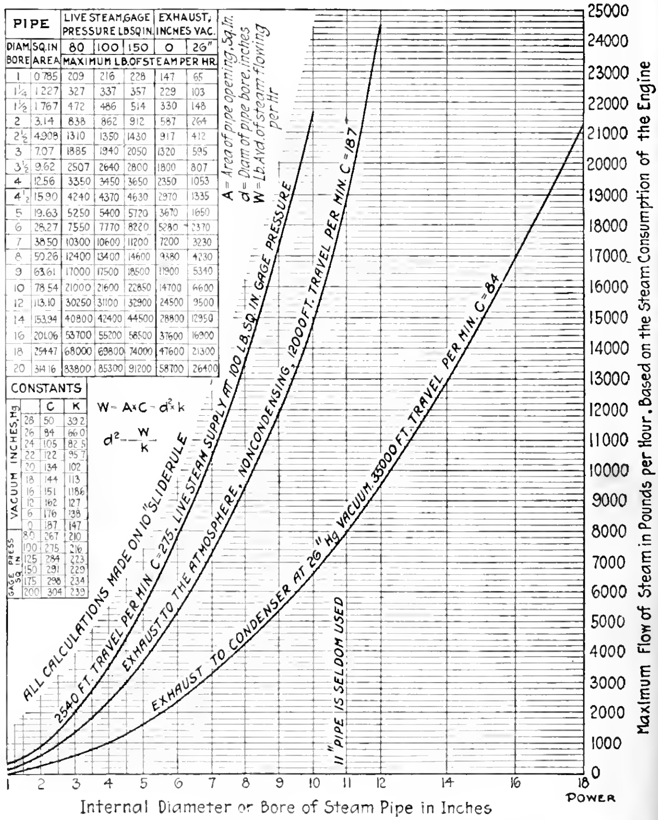
For the modern steam plant in a factory or the municipal plant of a small city, designed according to conventional practice and having a fair grade of reciprocating engines set close to the boilers, it is much more convenient to calculate pipe sizes from the gross pounds of steam per hour required by the engine at the best rated load and make use of a formula based on the most suitable pipe size as established by several decades of good commercial practice.

The old rule-of-thumb would answer but for the fact that during the past few years some of the engine builders have increased the rated speeds of their engines—and therefore the rated horsepower and steam consumption—without apparently increasing the pipe sizes, and in some cases wire drawing results; whereas, if these simple formulas were used for the pounds per hour and the pipe sizes chosen accordingly, the wire drawing would not be higher than that heretofore established as good practice.

The curves and constants given in the chart are from the mean curves found by plotting the results of data obtained of sizes of engine pipes used in a large number of successful power plants. The maximum and minimum curves were quite irregular, but they appeared to vary up to about 10 per cent. of the mean values.

As illustrating the use of the table, take the case of a 14x36-in. noncondensing Corliss engine under 100-lb. steam pressure by gage, and running 100 r.p.m., which is rated by the builders at about 135 i.hp. at 1/4 cutoff (the rating of different builders varies somewhat), and assume such an engine at that load to take 26 lb. of steam per hour, which is about what many engine builders guarantee in their contracts for such a size under these conditions. There is then 135 i.hp. × 26 lb., or about 3500 lb. of steam per hour, and looking on the chart the nearest sizes are found to be 4-in. steam pipe and 5-in. exhaust, which sizes are as small as one should like to make them for ordinary conditions of plant arrangement.

In special cases of very large plants or long steam mains, the drop in pressure from pipe friction should be calculated. Perhaps that method of choosing pipe sizes should be followed, but the table will be found useful for a large percentage of the cases arising in practice.



PIPE		LIVE STEAM, GAGE PRESSURE LB. SQ. IN.			EXHAUST, INCHES VAC.	
DIAM. BORE	SQ. IN. AREA	80	100	150	0	26"
		MAXIMUM LB. OF STEAM PER HR.				
1	0.785	209	216	228	147	65
1¼	1.227	327	337	357	229	103
1½	1.767	472	486	514	330	148
2	3.14	838	862	912	587	264
2½	4.908	1310	1350	1430	917	412
3	7.07	1885	1940	2050	1320	595
3½	9.62	2507	2640	2800	1800	807
4	12.56	3350	3450	3650	2350	1053
4½	15.90	4240	4370	4630	2970	1335
5	19.63	5250	5400	5720	3670	1650
6	28.27	7550	7770	8220	5280	2370
7	38.50	10300	10600	11200	7200	3230
8	50.26	12400	13400	14600	9380	4230
9	63.61	17000	17500	18500	11900	5340
10	78.54	21000	21600	22850	14700	6600
12	113.10	30250	31100	32900	24500	9500
14	153.94	40800	42400	44500	28800	12950
16	201.06	53700	55200	58500	37600	16900
18	254.47	68000	69800	74000	47600	21300
20	314.16	83800	85300	91200	58700	26400

CONSTANTS

		C	K
VACUUM INCHES, Hg	28	50	39.2
	26	84	66.0
	24	105	82.5
	22	122	95.7
	20	134	102
	18	144	113
	16	151	118.6
	12	162	127
	6	176	138
	0	187	147
GAGE PRESS. SQ. IN.	80	267	210
	100	275	216
	125	284	223
	150	291	229
	175	298	234
	200	304	239

Sizes of Pipes for Steam Engines, Based on Successful Practice

❊

Ignorance—A visitor who could tell about volts and amperes was walking through a 110,000-volt substation pointing at high-tension oil switch leads with an umbrella that had a steel stick in it. The foreman put him out before the current got a crack at him.

❊

Laborer Cooling a Hot Box over a 650-volt third-rail with a metal pail of water that had been salted to prevent freezing: They succeeded in bringing him to.

Capacity and Power of Hydraulic Pumps

By R. A. Lachmann

The accompanying tables provide a ready means of ascertaining the power and capacity of a plunger pump. Although computed for single-acting pumps with a slip of 5 per cent., and working against a pressure of 1000 lb. per sq.in., they may, by a few simple calculations, be made to apply to any direct-acting pump. A couple of examples will make this clear.

TABLE 1—CAPACITY AND POWER OF SMALL SINGLE-ACTING HYDRAULIC PUMPS

No. of Plungers	Diameter of Plungers, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
	½		28	0.12				0.1
1	⅝		44	0.19				0.15
	¾		63	0.27				0.2
	½		56	0.24				0.2
2	⅝	1½	88	0.38	100	25	1000	0.3
	¾		126	0.54				0.4
	½		84	0.36				0.3
3	⅝		132	0.57				0.45
	¾		189	0.81				0.6
	½		37	0.16				0.13
1	⅝		59	0.25				0.2
	¾		84	0.36				0.27
	½		75	0.32				0.27
2	⅝	2	117	0.51	100	33	1000	0.4
	¾		168	0.72				0.53
	½		112	0.48				0.4
3	⅝		176	0.76				0.6
	¾		252	1.08				0.8
	½		47	0.2				0.16
1	⅝		73	0.32				0.25
	¾		105	0.45				0.33
	½		93	0.4				0.33
2	⅝	2½	147	0.63	100	42	1000	0.5
	¾		210	0.9				0.66
	½		140	0.6				0.5
3	⅝		220	0.95				0.75
	¾		315	1.35				1.00
	½		56	0.24				0.2
1	⅝		88	0.38				0.3
	¾		126	0.54				0.4
	½		112	0.48				0.4
2	⅝	3	176	0.76	100	50	1000	0.6
	¾		252	1.08				0.8
	½		168	0.72				0.6
3	⅝		264	1.14				0.9
	¾		378	1.62				1.2

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

TABLE 2—CAPACITY AND POWER OF LARGE SINGLE-ACTING HYDRAULIC PUMPS, SINGLE PLUNGER—¾-IN. TO 1¾-IN. DIAMETER

Diameter of Plunger, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
¾		168	0.72				0.53
⅞		229	1.00				0.72
1		298	1.29				0.94
1⅛		378	1.64				1.20
1¼	4	466	2.02	100	66	1000	1.48
1⅜		564	2.44				1.78
1½		672	2.91				2.12
1⅝		788	3.41				2.49
1¾		915	3.96				2.90
¾		210	0.90				0.66
⅞		286	1.25				0.90
1		373	1.61				1.18
1⅛		473	2.05				1.50
1¼	5	583	2.53	100	84	1000	1.85
1⅜		705	3.05				2.23
1½		840	3.64				2.65
1⅝		985	4.26				3.11
1¾		1144	4.95				3.62
¾		252	1.08				0.80
⅞		344	1.50				1.08
1		447	1.94				1.41
1⅛		567	2.46				1.80
1¼	6	700	3.03	100	100	1000	2.22
1⅜		846	3.66				2.67
1½		1008	4.37				3.18
1⅝		1182	5.12				3.74
1¾		1373	5.94				4.35

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

Assume a two-plunger pump with ¾-in. plungers, a 2½-in. stroke (the movement of the plunger in one direction) and a speed of 100 r.p.m. when working against a pressure of 1000 lb. per sq.in. Under these conditions the capacity and necessary horsepower can be read directly from Table 1.

First, look for 2½ in. under the heading "stroke;" then the number 2 in the column headed "number of plungers," and opposite this for the plunger diameter of ¾ in. Following this line to the right, there will be found the desired information under the respective columns: that is, the capacity in cubic inches per minute will be 210, the capacity in gallons per minute will be 0.9, and the horsepower required to drive the pump will be 0.66. A 1-hp. motor would probably be selected.

TABLE 3—CAPACITY AND POWER OF LARGE SINGLE-ACTING HYDRAULIC PUMPS, SINGLE PLUNGER—1⅞-IN. TO 4½-IN. DIAMETER

Diameter of Plunger, Inches	Stroke in Inches	*Capacity in Cu.In. per Min.	*Capacity in Gal. per Min.	Revolutions per Min.	Speed of Plunger in Ft. per Min.	Pressure, Lb. per Sq.In.	†Horsepower Required to Run Pump
1⅞		1049	4.54				3.31
2		1194	5.17				3.77
2¼		1511	6.54				4.77
2½		1865	8.07				5.89
2¾	4	2257	9.77	100	66	1000	7.12
3		2686	11.63				8.48
3½		3656	15.83				11.54
4		4775	20.67				15.07
4½		6044	26.16				19.08
1⅞		1311	5.68				4.14
2		1493	6.46				4.71
2¼		1889	8.18				5.96
2½		2331	10.09				7.36
2¾	5	2821	12.21	100	84	1000	8.90
3		3358	14.54				10.60
3½		4570	19.79				14.43
4		5969	25.84				18.84
4½		7555	32.70				23.85
1⅞		1574	6.81				4.97
2		1791	7.76				5.66
2¼		2267	9.81				7.16
2½		2798	12.11				8.84
2¾	6	3386	14.66	100	100	1000	10.68
3		4029	17.45				12.72
3½		5484	23.75				17.31
4		7163	31.01				22.61
4½		9066	39.24				28.62

*Figures given are 5% less than the theoretical capacity, on account of loss due to slippage.
†Figures given are 25% more than the theoretical horsepower, allowing for friction.

Now assume the following conditions: Stroke, 2½ in.; diameter of plungers, ¾ in.; number of plungers, 4; speed, 150 r.p.m.; pressure, 1700 lb. per sq.in. Find the capacity and the horsepower required.

As the quantities and sizes involved are directly proportional to those in the table, first double the quantities given for two ¾-in. plungers; this gives the first multiplier, namely 2. Then since 150 r.p.m. is 1.5 times 100 r.p.m., shown in the table, the second multiplier will be 1.5. The third multiplier is 1.7, since 1700 lb. is 1.7 times 1000 lb. The product of these three multipliers is:

$$2 \times 1.5 \times 1.7 = 5.1$$

which is the common multiplier. Then the capacity is

$$5.1 \times 210 \textit{ cu.in.} = 1071 \textit{ cu.in. per min.}$$

$$5.1 \times 0.9 \textit{ gal.} = 4.59 \textit{ gal. per. min.}$$

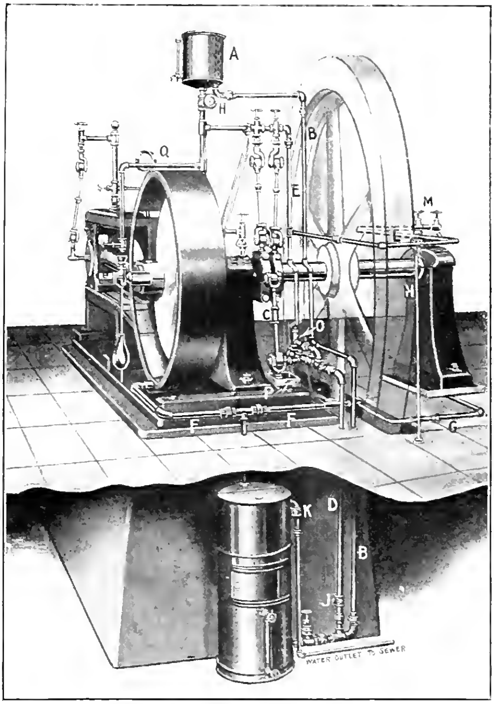
and

$$5.1 \times 0.66 \textit{ hp.} = 3.366 \textit{ hp.}$$

or about 3½ hp. would be required.

Nugent Pressure Return Oiling System

From time to time in these columns the various Nugent lubricating devices, such as the pendulum crankpin oiler, the antipacked telescopic oiler for crossheads and eccentrics and the illuminated oil filter with the automatic water separator, have been described. For about a year, however, the company has been combining these various devices into a complete pressure system for individual units, such as is shown in the accompanying illustration.



Nugent Oiling System

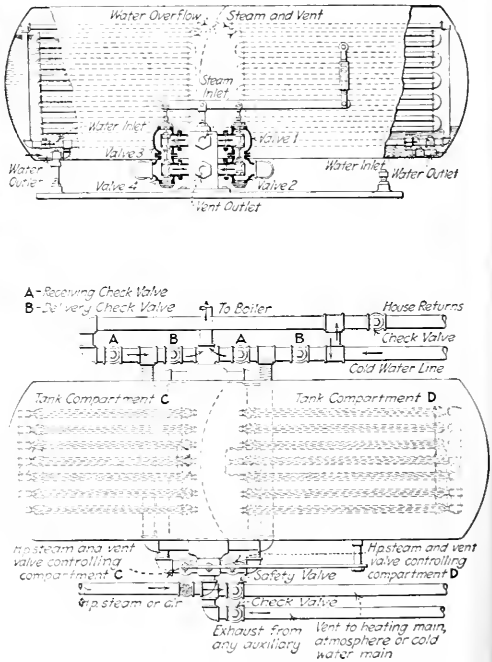
A simple plunger pump actuated by the engine eccentric draws the oil through the pipe *D* from the storage space of the filter. The oil is forced to the system on the engine and to the reservoir *A*, which is provided with a gage glass and an overflow leading from the top of the tank. The oil flows back to the filter through the pipe *B*. By manipulating the valve *H* any pressure up to 25 lb. can be maintained on the system. A check valve *J* prevents oil returning to the filter through the suction. Open-sight feeds supply the oil to the various points of service, and drains *F*, *F* and *G* from the crankpit, eccentric pan and outboard pillow block return the oil to the water separator and oil filter shown under the floor. If any of the openings in the sight-feeds should become clogged, it is an easy matter to force up the pressure to the limit previously given and blow out the obstacle. The safety valve *O*, set at 25 lb., protects the system.

Pipes *L* and *M* convey the oil to the outboard bearing, *N* is a support for pipe *L*, *K* is a sight-feed in the water-outlet pipe leading to the sewer. *Q* is a gage to show the pressure on the system, and *P* is a drip pan for the oil pump. The system is thus complete in itself and is actuated by the unit it serves. If any trouble should develop it is localized to the one unit. Additional information may be obtained from W. W. Nugent & Co., Chicago, Ill.

Farnsworth Tilting Traps

A combined feed-water trap, heater and weigher is being marketed by the F. C. Farnsworth Co., Bush Terminal, Brooklyn, N. Y. The illustration shows a section of this tilting type of apparatus.

The tank has two compartments which fill and empty alternately. Instead of trunnions, flexible copper hose is used. Water is carried to the top of each compartment and distributed over the copper heating coil through a perforated pipe. First, the coil is heated by exhaust steam fed in through the vent valve. When the compartment fills with water its weight tilts the tank, interchanging the valve, venting the opposite side and simultaneously admitting steam at boiler pressure in the coil and



The Farnsworth Tilting Trap

out onto the surface of the water to force the latter into the boiler.

The trap may be furnished with or without the heater. A counter may be made to register the number of oscillations and the weight of water delivered calculated from the reading.

Traps acting on the same principle, but with modification of the inlets, outlets and partitions, are adapted to services such as those of a blowoff or condensate weighing tank and trap, and of sewage or water lifts using steam or compressed air.

Special Reconstruction Jobs*

By Osborn Monnett†

SYNOPSIS—Limited headroom and floor space call for unusual designs of setting not recommended for standard practice. Some interesting cases are presented.

Installing new boilers in old office buildings offers one of the most difficult problems the designer will encounter if smokelessness is one of the prime considerations. Fig. 1 shows how it was done in a plant requiring additional boiler capacity with limited floor space and headroom in which to install it. It was necessary to provide 100 boiler-hp. in a floor space of 7 ft. 5 in. by 8 ft. 5 in. and a headroom of 10 ft. and to find room for a smokeless setting. The solution was a Worthington boiler of spe-

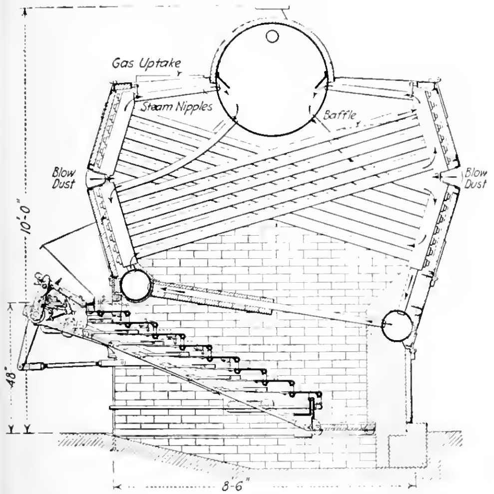


Fig. 1. Worthington Boiler, 100 Hp., and Moore Stoker

cial design in which the rear mud drum extended some 18 in. below the normal position and connected with the front mud drum by 2½-in. tubes, spaced 4 in. on centers. It gave 48 in. of free space between the bottom of the front mud drum and the floor line and provided opportunity for a tile roof on the tubes connecting the mud drums. Strong ignition for a Moore stoker installed directly under the boiler was thus obtained. This unit has met every requirement of floor space and headroom and is running smokelessly on loads up to 40 per cent. above rating. The same combination in almost any capacity can be supplied by simply adding to the width of the setting without increasing the headroom or floor space in a lengthwise direction.

Fig. 2 is another application of the Worthington boiler to limited floor space. The floor space occupied by the boiler is 10 ft. 2 in. wide by 11 ft. long, while the stoker adds 3 ft. 3 in. to the length. The headroom to the steam nozzle of the boiler is 16 ft. This unit is of 300 boiler-hp. capacity. The ignition arch is 6 ft. long, with a low-pressure water-back furnishing a permanent support for the built-up bridge-wall. Between the two, good throat action is obtained, insuring complete combustion and good economy. The arch is supported by another low-

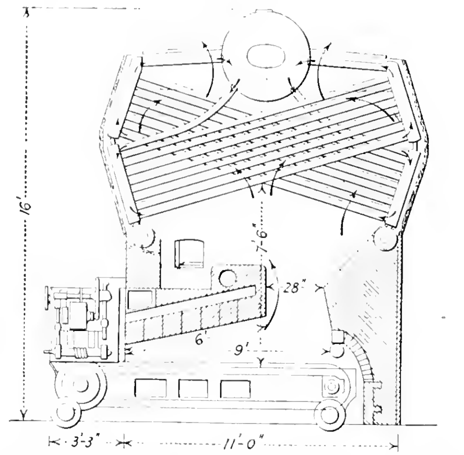


Fig. 2. A 300-Hp. Worthington Boiler and Chain Grate on Limited Floor Space

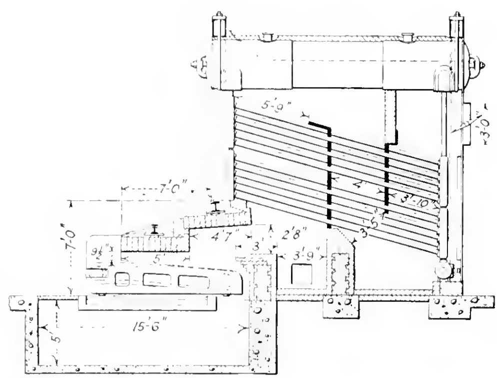


Fig. 3. A 390-Hp. B. & W. Boiler and Laclede-Christy Chain Grate; 7-Ft. Headroom and 7-Ft. Extension

pressure water-back and provision is made for ventilation over the arch to insure satisfactory life.

The horizontal water-tube boiler, vertically baffled, equipped with a chain grate, short ignition arch and short flame travel, is frequently encountered. This type of setting is a constant smoker. It is true that the smoke may not at all times be dense enough to be a violation, but there is hardly a moment in the twenty-four hours during which No. 1 or No. 2 smoke on the Ringelmann chart

†Smoke inspector, City of Chicago.

is not emitted. This is due to the volatile matter being chilled by the nest of tubes before combustion can be completed. Frequently the setting is erected with only 6-ft. space from the floor line to the front header, so that considerable remodeling is necessary before good results may be expected.

The best method of cleaning up these settings is by raising the boiler or lowering the floor, and putting in horizontal baffles. A good illustration of this is given in Figs. 1 and 3 on pages 532-3 of the Oct. 13 issue. Sometimes the boiler is set high enough so that only the combustion-chamber floor need be lowered when the horizontal baffle is put in. In any case, liberal space must be provided in the combustion chamber to avoid "bottling" the hea , and therefore burning up the arches and tiling. Occasionally, when floor space is to be had in front of the boiler, it has been possible to pull out the stoker and get enough flame travel to clean up the setting.

A case of this kind, Fig. 3, consists of a B. & W. boiler with a Laclede-Christy chain grate in 7 ft. of headroom, built out 7 ft. from the gate to the flue caps and having a 5-ft. flat ignition arch, followed with a 4-ft. 7-in. secondary arch. This unit operates smokelessly and may be considered satisfactory up to rated capacity. Of course, such a setting cannot be considered good for capacities above rating, but it can be taken as a reconstruction possibility where conditions permit.

Results of Changes in Boiler Furnace

By Morgan B. Smith*

SYNOPSIS—A specific instance where the efficiency of two 500-hp. Stirling boilers, each fitted with two Roney stokers, was greatly increased by enlarging the combustion chamber or furnace.

At the instance of E. J. Burdick, superintendent of power, Detroit United Railway Co., the writer in conjunction with F. L. Fisher, Chief Engineer of the Rochester, Mich., power station, carried out at the company's laboratory an extensive investigation of the rate at which combustion progresses in Stirling boilers, each having two Roney stokers.

This investigation showed that completion of combustion is delayed at a point too far back in the gas travel when such boilers are fitted with Roney stokers and restricted combustion chambers, as is the case when each stoker is housed in a separate furnace and long combustion arches are used. Combustion was never complete short of the bottom of the second pass and at times not even half-way up the last or third pass. This was manifestly bad practice, resulting in the production of dense smoke and relatively low efficiency.

It is obvious that the cure for this condition lay in so designing the furnaces as to assure quicker completion of combustion before the gases turned downward into the second pass. It was believed that less restriction of the gases would give this result and that less smoke would be produced; higher efficiency ought also to be attained. With a less restricted combustion chamber the volatile constituents in the fuel would be distilled less rapidly, owing to lower furnace temperatures, and less smoke would result as these products would have time for complete ignition before impinging on the relatively cool tube surfaces.

We determined to gradually cut away the long arches and note the results after prolonged operation. In this we were disappointed, for the division wall in one of these boiler furnaces, already weakened, gave way and let both arches down. There was nothing to do but to clear away the mass of firebrick and get the boiler back on the line as soon as possible. Advantage was taken of this new state of affairs by making a thorough study of the boiler operation without arches, comparing this to the old operation with the arched furnaces.

The division wall was trimmed down to follow the line of the grates (inclined) and made 6 in. higher. We now had one large high furnace with no division wall to break up the flow of the furnace gases. We found that we must protect the front wall of the setting, so we extended the coking arch 10 in. inside this wall, battering it back against the wall, at the same time protecting the structural-steel frame at the front of the boiler. This gave 22 in. of coking arch, the only arch in the furnace. We also increased the height of the first or front baffle one foot, giving 13 sq.ft. more baffling surface, a longer gas-travel, and a reduction of the breeching temperature.

These boilers have been in operation six months and as a result of the efficiency attained we are similarly modifying all of these furnaces. It is expected to have a Stirling boiler fitted with Murphy stokers in satisfactory operation without any arch in a short time.

In all our power stations we reduce the results to a basis of kilowatt-hours obtained per million heat units supplied to the furnaces. The data given below show the results obtained since taking out the long arches as against results with long arches—i.e., large, unrestricted combustion spaces against small, confined spaces.

COMPARATIVE OPERATION

	Restricted Spaces	Unrestricted Spaces
Combustion arch, in.	72	None
Coking arch, in	12	22
Division wall, in	72	72
Height above grate, in	Full	6
Kw. hr. per million B.t.u.	17.50	23.52
Breeching temperature, deg. F	560	558
CO_2 average at the breeching, per cent	9.00	12.50
Smoke by Ringelmann charts, average	No. 3.	Average less than No. 1
Temperatures in boiler:		
Over fires, deg. F	2462	2092
Bottom of front tubes, deg. F	2370	2000
Top of first pass, deg. F	1000	1175
Bottom of second pass, deg. F	690	710
Top of third pass, deg. F	570	558
Ashes produced:		
Ash-in-ashes, per cent	69.34	79.74
Combustible in ashes, per cent	30.66 (by diff.)	70.26
Draft losses—taking draft at breeching side of back damper as 100 per cent.:		
Under grates, per cent	8.25	8.25
Over grates, per cent	34.50	34.50
Top of first pass, per cent	40.00	35.50
Bottom of second pass, per cent	48.50	50.00
Top of third pass, per cent	67.50	69.50
Boiler-side of back damper, per cent	92.50	93.50
Breeching-side of back damper, per cent	100.00	100.00

All draft readings were taken with the inclined tube type of draft gage, reading directly to 1/100-in. water pressure.

The electrical unit operated during this period consisted of a 2000-kw. alternating-current generator driven

*Chief chemist and combustion engineer, Detroit United Railway Co.

by a turbine fitted with a jet-type condenser. The load varies from 1250 to 2500 kw. and is difficult to handle economically because of frequent peak-load conditions of short duration.

The coal figures in the table include the daily three and one-half to four hours of banking during the night. All coal received is sampled and tested for heat value in a standard Atwater bomb calorimeter and the wattmeters are checked frequently with master meters.

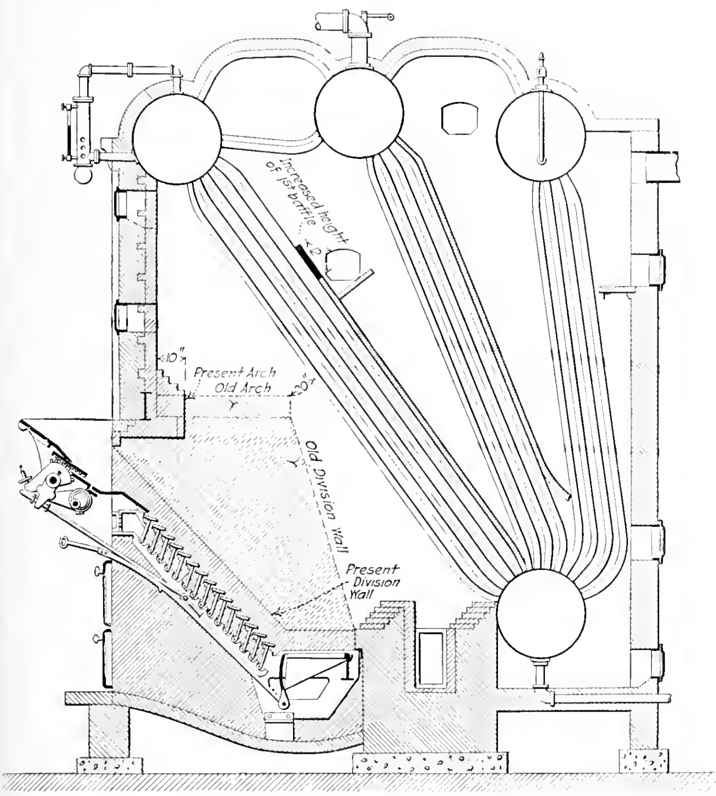
COAL FIRED (Average)

All coal is dried at 105 deg. C. for one hour before testing. Coal received averages 10 per cent. moisture at the stations.

B.t.u. per lb	13 962
Volatile matter, per cent	36 77
Fixed carbon, per cent	54 33
Ash, per cent.......	8 90
Sulphur (Eschka), per cent.......	2.18

CONDENSER DATA (Average)

Condenser intake, temperature, deg. F.....	53 5
Condenser discharge, temperature, deg. F	73 3
Average vacuum produced, mercury, in......	28.5



SHOWING THE OLD AND THE NEW ARCHES

The turbine water-rate is approximately 14 lb. under operating conditions. To handle the load requires that the two boilers shall run at an average of from 160 to 175 per cent. of rating.

Points noted in the operation of these boilers with modified furnaces are:

1. Virtually no smoke is produced, a mere haze being visible most of the time. No soot of a black, oily nature is made, the accumulation on the tubes and around the clean-out doors being more like fire-clay than soot.

2. More even heat absorption in the three banks of tubes is attained. The front bank is greatly relieved of the high heating effect of the gases as they travel over the old arch. Both the second and third banks of tubes do more work. The front bank will show longer life than with the arched construction.

3. Deterioration of the grates is less, due to lower furnace temperatures.

4. Better quality flue gases are obtained, no CO being found until the CO_2 reaches 16 per cent. The average CO_2 figures given are somewhat lower than the true maximum because of the loss of from 1 to 1.5 per cent CO_2 in air of infiltration through the boiler settings.

5. Less coal and ashes are handled, also less soot.

6. Cost of firebrick arches is eliminated.

7. Peak loads are carried more easily because we can burn more coal in a given time than before.

8. The water level in the boilers does not surge as before because the front bank of tubes is heated almost uniformly throughout its length.

9. There seems to be no need of a fourth pass in the gas travel, although this might improve the efficiency if it did not unduly cut down the draft available (natural draft; chimney 200x10 ft.).

10. Combustion is now completed before the gases turn downward into the second pass, except when the boiler is being pushed above 175 per cent. of rating, at which times combustion is carried further into the passes, being completed at the middle of the second pass. As these boilers seldom exceed 160 per cent. of rating, the object of these experiments may be said to have been accomplished. The slower rate of distillation of the volatile matter in the fuel together with better mixing conditions (volatile matter with oxygen) is the secret of the elimination of smoke.

We believe that these boilers should be set 1 ft. higher than at present, in which case even better results should be attained with the given fuel. Choice of fuel has much to do with furnace and boiler-setting design; too little attention is given to such items. With higher boiler settings the brickwork is increased and the danger of leaky settings is augmented, but with settings properly incased this should not cause alarm.

Tension on Brushes should be set by the aid of a small spring balance, so that all the brushes will bear with an equal pressure. This refers especially to high-speed machines; the pressure will vary from about 8 to 10 oz. per sq.in. of brush surface in slow-speed machines up to 1¼ lb. in the high-speed types.

Concrete Filling for Engine Beds and Machine Frames

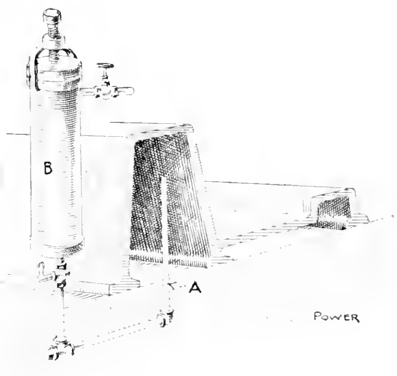
By F. W. Salmon

Should the bed of a large engine or generator be filled solid with concrete? A concrete filling will tend to absorb the vibration, reduce the noise from pounding and give the bedplate a larger and better bearing upon the foundation.

I have had bedplates filled with concrete, and it has always proved advantageous. Some of these have been filled before erection by turning the bedplate bottom-side up and filling the space with a mixture of one part of portland cement to three or four of clean sharp sand, and allowing it to set.

If the engine or machine is already erected and loose on the foundation, or acts like a piano sounding-board, it can be easily filled in the manner shown in the illustration. A small air vent, ¼-in. pipe size, is tapped at the highest point of each compartment or space. The old grouting is channeled out and pipe *A* put in and well grouted in place with equal parts of portland cement and sand.

The charging cylinder *B* can then be screwed on and connected to a supply of compressed air. Grout is put in, the cylinder quickly closed, and a light pressure of air—say 10 to 30 lb.—is turned on to drive the grout into the space to be filled. Do not allow any grout to stand in the pipes or the cylinder, as it will set. Blow the grout out clean each time as soon after filling as possible and at night take down cylinder *B* and wash it clean with water.



Means of Filling Hollow Bedplates

In many cases this work is done gradually, a little put in one day, more the next, and so on. The pipe *A* should extend nearly to the top of the inside of the frame in every case, so that the grouting cannot run back into it, while refilling the cylinder *B*.

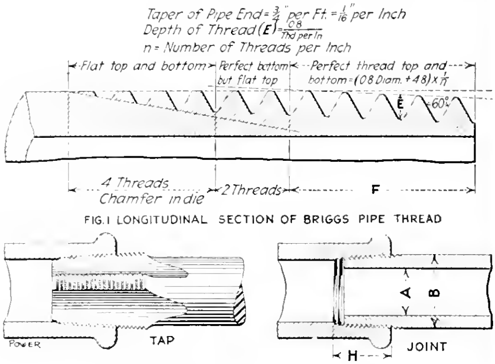
In a few cases, I have had a little air pressure kept on the top of the concrete during the time it was setting, thus insuring the concrete being in good contact with the inside of the bedplate at all points, but care must be exercised to avoid springing the bedplate.

Sand, of course, may be used after a small layer of concrete has been introduced and has hardened, but solid concrete is more desirable in every case as it reduces the vibration and noise much better than sand and gives the bed greater support.

My experience is that filling an engine or heavy machine bedplate with concrete costs but little and is a good thing to do.

Standard Pipe Threads

The illustration under the above heading in the issue of Nov. 3, p. 646, is not correct in that threads *F* should



Briggs' Standard Pipe Thread

be perfect at top and bottom to agree with the text, and the decimal point is missing in one formula. The new illustration herewith is corrected in these particulars.

The Sediment in a Boiler will accumulate in the portion of the bottom near to the region of the bridge-wall in the furnace; and if you have no such thing as a bridge-wall it will accumulate where the fire is hottest. This is a result of heat movements that send the hot water upward from highly heated spots while the cooler water surrounding sweeps in below, carrying with it sediment that builds a little mound, if there is some one spot that is materially hotter than the rest of the surface exposed to the fire.

In a Refrigerating Plant, if one wishes to obtain the best results, the machinery should be run regularly and evenly; otherwise things will go wrong. When excessive quantities of liquid come back to the compressor, the compressor piston-rod stuffing-box will start to leak. It is bad practice to tighten up on the stuffing-box glands because the rod contracts when cold, but when the frost disappears it becomes hot and expands again so that the leak will disappear; otherwise the packing will burn when the rod expands. When the frost comes back to the machine on account of low steam pressure, which causes the machine to slow down, the best thing to do is to shut the main liquid valve for a while or stop the machine, after having pumped the low-pressure side down to zero pressure, until the steam pressure rises again.

Often, when the frost comes from one room very strongly, it may back up into all the other returns and then it is hard to tell by looking at them which is the one that is doing the damage, or if there are several returns giving trouble, which one freezes back the most. By wetting the finger tips and touching each return, the one that sticks to the fingers most readily is the one that should be turned off some. It is good practice to have marks of some kind on each expansion valve so placed that one can tell exactly how much was turned on or off.

If a refrigerating machine is to be stopped for a little while only, and the valves in the compressors are in good order, the discharge stop valves may be left open, but never the suction stop valve. This should be an engine-room rule.

Editorials

Driving Boilers and Burning Tubes

The author of the "Mechanical Engineers' Pocketbook" favors our correspondence columns with some observations upon our recent remark that "scale or oil which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface is very likely to make trouble when the evaporation goes up to six or ten pounds." He points out that with an average evaporation of three pounds per square foot per hour there may be times, as just before firing a fresh supply of coal, when the rate of transmission of heat may be equivalent to an evaporation greatly in excess of this figure. That is, one must not assume, because his boiler averages three pounds per square foot per hour, that it may not be working some of the time at the higher and more dangerous rate. His observation that the temperature of the fire is almost independent of the rate of driving seems to be irrelevant if it is the driving of the fire which is meant, but it is difficult to see, notwithstanding the reference to driving the boiler which follows shortly, how a hotter fire can be maintained without a corresponding increase in the rate of evaporation.

New York City's Proposed License Bill

It seems to be a never-ending duty of ours to remind engineers and legislators that some folks in this land are guaranteed a right to a livelihood by the Constitution of the United States, if not by the exercise of that sense of justice which civilized beings should manifest. If it were not so easy for those of the medical, pharmaceutical and other professions to kill the children of men, their possible victims would not require that they be certified by a license of competency. If steam boilers and engines were not veritable infernal machines in the hands of the unskilled, if they had not caused an appalling loss of life and property, the public would not seek to protect itself by inquiring into the correctness of their structure or the fitness of their operators.

Safety is the object, the end, the all, of such laws. But unfortunately, some engineers want to corner their local markets for engineers and to do it under the guise of public safety. They want to say to their fellow engineers: "Here, this territory is ours. No matter how badly you need a job, or how good the job is that you are after, or how competent you are to fill it, you cannot have it because you have not lived here one, three or a dozen years." It seems almost incredible that men should attempt to legalize and statutize their selfishness, yet they do. The laws of Buffalo and New York City are well known examples, but any law that denies the right of aliens to follow their trade or profession in any state, on the same footing as any citizen of that state, is unconstitutional and would be nullified the first time it was taken to court. Some engineers of New York City do not know this and have proposed a bill for the creation of a separate bureau in the department of licenses for the inspection of certain steam boilers and the examination and licensing of engineers and firemen. First, they wish to create the offices of superintendent of inspection, two general inspectors, two examiners, nine boiler inspectors, and other subordinates, and make all jobs appointive by the commissioner of licenses. It is not deemed advisable to examine into the competency of these appointees.

Applicants must be subjected to a physical and practical test of their fitness. The practical part is all right, but the physical test is nonsense.

A man must be twenty-one years old to get a fireman's license. Candidly now, how many of those who participated in the making of this bill were firing boilers before they were twenty-one? And do those who were believe now that they were not men enough for their jobs? Certainly not. That section of the bill is also ridiculous.

Worst of all is the section which states that "No such applicant (engineer) shall receive a license as engineer unless he is able to keep accurate data of the cost of operation and maintenance of boilers and steam machinery."

Much as we urge engineers to acquire such ability, we would not include its possession as a license-law requirement, for law is for safety, not to confer special privileges on certain classes, and safety does not depend on the knowledge above mentioned. Some men can operate plants safely who would make a poor showing before examiners as power-plant economists.

Surely, the engineers of New York City will kill this bill before its gets into Albany. Is it any wonder New York State cannot enact a state license law?

Specifying Unit Station Costs

In comparing the cost of generating plants it is always interesting to reduce the figures to the unit basis, but in many cases insufficient care is taken to specify just what units are in mind. In a typical instance the cost of an electric plant was found to vary from $45 to $125 per kilowatt, according to the selection of the factor divided into the total outlay in money. It is important in making such calculations to state whether one means cost per kilowatt of existing total rated capacity, cost on the basis of maximum sustained output for a protracted period of specified length, cost per kilowatt of plant completed to the ultimate capacity of the existing building, or whatever the factor of selection may be. Engineers are often a bit careless in this, with the result that figures do not always afford accurate deductions.

Sometimes, for example, a coal-handling equipment suitable for the proposed ultimate capacity of a given plant is provided long before all the engine or turbo units planned for have been installed. If the full cost of this equipment is included in the unit determination for the station on the basis of perhaps a half of the ultimate number of generators and boiler batteries, one gets a different result from that obtained by making an allowance for that portion of the coal-handling plant required by present service and making a note to that effect on the estimate sheet.

Similarly, when a few units are housed in a building large enough for a substantial increase in capacity, one gets a relatively high building charge if a cost determination is made on the basis of the existing generating units. Figures of this kind are instructive and well worth assembling, but where they are prepared for an installation not yet complete according to the full plans, the fact should be made known in presenting unit cost data, so that a reasonable allowance can be made by those to whom the data are submitted.

It is often needless to attempt to separate that part of the cost of buildings or auxiliary apparatus such as stacks and condensing water tunnels chargeable to present plant from the ultimate station capacity cost, for in very large stations the boiler batteries and main units cost so much more than the auxiliaries that a considerable variation in the outlay for the latter produces but a comparatively small change in the unit result. That is, a building with sufficient house room to accommodate four 15,000-kw. turbo units and their necessary boilers will probably not cost enough more for the fourth unit to render valueless figures of unit outlay based on the total building space, even where only three machines are at first put in.

To return to the starting point, one may figure unit cost on any basis he pleases, and with profit, but unless that basis is definitely specified along with the figures deduced, misinterpretations and wrong comparisons are likely to spring up and cause trouble all around.

Concerning Expense Accounts

On the rare occasions when operating engineers are sent on business trips, they should realize the importance of their expense accounts. The way in which such accounts are rendered makes or mars the engineer's business reputation, and probably will affect his future advancement. Artists, scientists and even practical engineers are popularly considered as constitutionally unbusinesslike, and the more one studies the reasons for personal advancement, the more convincing is the evidence that clear-cut thinking and writing, methodical ways of doing things and an appreciation of the monetary side of affairs are powerful factors in the advancement of technical men to positions of executive responsibility.

The expense account is practically as important in the impression it makes upon the employer or superior officer as is the report of the engineer's trip. A man may go to a distant city, obtain the desired data, embody it in a valuable report and return home feeling that he has "made good" at the task in hand, but unless he turns in an expense account which can be roughly checked or audited by the man who "O. K.'s" the bill, he misses a real opportunity. A slovenly penciled memorandum of funds expended or a carelessly compiled group of items which yield no definite information as to the cost of main outlays, like transportation, hotel fare, cab or horse hire, telephone and telegraph expenses or important incidental disbursements made necessary by the trip, does the engineer positive harm.

The "boss" may not think anything about the matter, and then, again, he may. He may say to himself some time, "Johnson has gone over to Erie and got just the figures I wanted; he has put them down in the way I like; that fellow's got a clear head and his expense account shows that he has some business horse sense besides knowing a lot about steam engines and generators. I'm going to keep my eye on him and see if I can't work him up to take some of these details off my mind, and maybe make him assistant superintendent some day." There is nothing impossible about such a train of thought as this, and while it does not run through the individual employer's mind often, it is mighty important when it does—to the fellow who is striving to get ahead.

Needless to say, the right kind of a man will be as careful about squandering his employer's money as his own. This does not mean stopping at the cheapest hotels, for a first-class concern will wish its representatives to travel in reasonable comfort.

As one of the auxiliary matters, the proper handling of which will contribute to the sum total of impressions which lead to good repute, the engineer's expense account when away from home deserves thoughtful consideration.

Just for Fun

Send us the story of any piece of rank stupidity on the part of a power-plant employee that to your mind beats those in "Some Original Ideas," page 81. Just at present the fellow who gilded the commutator holds the palm. We do not wish to give much space to accounts of foolishness, but a limited number of the best letters received will be used. They will amuse all and instruct some perhaps.

Engineers' Study Course

The section on Power-Plant Design concluded with last issue. Four individual lessons not classified as a section, as were most of the previous ones, will appear, beginning with this issue, and these will end the Study Course, for the present at least. These last four lessons will be: "The Conversion of Energy" (page 103), "The Efficiency of Heat Engines," "Heat-Engine Cycles," and "Steam-Engine Cycles."

Those who bind their volumes of POWER, or who desire an index to facilitate reference to the filed copies, can have such an index by simply signifying their desire to the Subscription Department of POWER. An index is printed upon the completion of each half year, and is furnished free to all who care to have it.

Out in Ohio the following is what they require in an engineer-janitor:

ENGINEER-JANITOR for large building; must be a man of good habits and willing to work, otherwise we cannot use you. State age, size of family, experience; give names and addresses of four responsible parties as references.

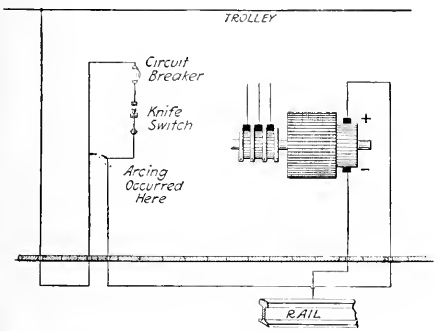
If this is a movement against race suicide we could suggest further qualifications with perhaps a little more emphasis on the "experience," for anyone in charge of a steam boiler has it in his power to reduce population.

Correspondence

Unusual Experience with Rotary Converter

During a severe electrical storm in northwestern Ohio an unusual phenomenon was produced by lightning on a rotary converter. The machine is part of a portable substation located in a box-car and which may be operated in parallel with the permanent substations on any desired section of the line.

No lightning protection was provided either on the 13,000-volt, alternating-current side or the 600-volt direct-current trolley side, the operator having instructions to shut down during lightning storms and pull all the switches.



Diagram, Showing Where Arcing Occurred

At the beginning of this particular storm, the operator pulled all the switches, consisting of the high-tension alternating-current switch, low-voltage starting and running alternating-current switches, the direct-current circuit-breaker and switches, the field breakup switch and the shunt-field switch.

Following an intense flash of lightning, the converter started to run, the direction of rotation being reversed, and the speed increasing at an enormous rate. The insulation on the wiring back of the switchboard was afire and produced a dense smoke which cut off a view of the leads and connections. As the machine had acquired such a high speed that it was likely to go to pieces, due to the centrifugal force on the armature, the operator telephoned the power station and ordered the power off the lines. This was immediately done, whereupon the converter came to rest, after a long period. The fire back of the switchboard was then put out.

An inspection of the rear of the switchboard revealed the fact that the lightning had struck the trolley at some point in the near vicinity and the heavy rush of current accompanying it had punctured the insulation and arced across two leads which were close together on the back of the switchboard. One of these leads was from the trolley to the direct-current busbar and the other was from the direct-current side of the converter to the bottom point of the direct-current switch. The trolley-to-rail current maintained this arc and flowed to the direct-current end of the converter which started as a series motor with no load. The sketch will make this clear. The only damage inflicted was upon the insulation at the rear of the switchboard, the converter not being injured in any way.

Frank W. Swift.

Toledo, Ohio.

Simplifying Reports of Boiler Tests

Mr. Morrison's letter in the Nov. 10 issue certainly touches upon a matter that requires to be put into clearer meaning than is usual at present. To simplify boiler reports, and make them of value to both directors and himself, the writer employs the following form:

Actual weight of water evaporated per pound of fuel (name of fuel).
Pounds of water evaporated for one cent.
Total cost to evaporate 1000 lb. of water, including labor.

Underneath for the writer's own information are:

Average percentage of CO_2.
Average temperature of feed water.
Average temperature of gases to chimney.
B.t.u. value of coal.
Amount of ash for given weight of coal.

With the first three items the directors can understand easily what the boiler plant is doing, and the remaining figures give the engineer all the particulars he really wants to know. If there are any peculiarities observed during the test, these are added in a footnote.

E. R. Pearce.

Rochdale, Eng.

Suggested Use of Terms Vapor, Steam and Gas

The terms vapor, steam and gas as applied to the gas-like condition of water expanded by heat, although meaning the same thing, are, unfortunately, often used as though referring to things that differ in their properties. We read of steam pressure and vapor pressure; that water flashed into steam or vapor. Often in books the words vapor and steam are both used; perhaps to avoid the too frequent use of either word.

To one familiar with the definitions there is no mental effort required to connect the two with a single meaning, but to the beginners this practice is more or less confusing, and still more so by steam being sometimes called a gas.

I have recently asked a number of engineers what they understood by these terms. The majority had the correct idea, but some had a hazy impression of some difference. One said that he understood vapor to be that which was given off the surface of water at ordinary temperatures, or below 212 deg., and that steam was given off at above 212 deg. This man knew that the composition of both was the same as water, but thought the two terms were used as a convenience to distinguish the difference in temperature. He understood the term gas to mean superheated steam.

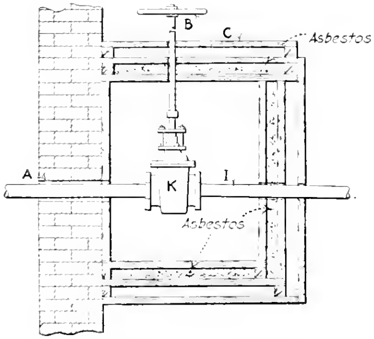
Now, if we must use the words vapor, steam and gas as applied to the expanded condition of water, it seems to me that the ideas of the engineer quoted would be more logical than mixing or using the terms interchangeably. We would then have vapor at temperatures below 212 deg., steam at above 212 deg. and gas as superheated steam.

C. O. Sandstrom.

Kansas City, Mo.

Keeping Blowoff from Freezing

I overcame a difficulty similar to that described by A. T. Rowe, page 788, Dec. 1, at a place where the



Box around a Blowoff Valve

temperature often drops to 30 deg. below zero. I built a double-walled box around the blowoff valve and filled the space between the walls with asbestos. The cover was inclined to allow the rain or snow to run off and was removable to give access to the valve when necessary.

A handle *B* is used to open and close the blowoff valve *K* without removing the cover. A space where the pipe passes through the wall at *A* admits a small amount of heat to the box. The pipe *I* has a slight slant so that no water can remain in it, and it has never frozen up during several years' use.

James E. Noble.

Toronto, Ont.

Forcing Boilers and Bursting Tubes

In the illustrated article on "Burst Boiler Tube" in your issue of December 8, page 805, the statement is made that "scale or oil, which will cause no serious overheating of the metal when three pounds are evaporated per hour per square foot of heating surface, is very likely to make trouble when the evaporation goes up to six or ten." This statement is apt to give an unwarranted sense of security to owners of boilers which are usually not driven at a rate of over three pounds evaporation per hour per square foot of heating surface. The fact is that when the rate of driving of a boiler averages this figure, there are times, when the fire is at its brightest, just before firing a fresh supply of coal, when the rate of transmission of heat may be equivalent to an evaporation greatly in excess of this figure.

Also, the rate of transmission of heat through the surface of the bottom half of the lower row of tubes, immediately above the fire, depends on the temperature of the fire, the temperature of the water in the tube, and the resistance to transmission of heat of any layer of scale or oil which may be on the surface of the tube. The temperature of the fire is almost independent of the rate of driving. It depends chiefly on the dryness of the coal, the completeness of the combustion, and the amount of excess air over that necessary to insure complete combustion. It is quite possible with either anthracite or semi-bituminous coal to have a temperature of 3000 deg. F. in the furnace, whether the boiler is driven at a moderate or at a high rate. Given a condition of firing which produces such a temperature, the rate of driving per square foot of heating surface depends upon the amount of heating surface that is provided for the absorption of the heat, and as this surface, or nearly all of it, is beyond the lower row of tubes immediately over the fire, it can have nothing to do with the establishing of a condition which would cause the burning out of a tube in the lower row.

If statistics of burst boiler tubes should show that bursting is more frequent at high rates of evaporation, it does not follow that the high rate of evaporation in itself is the cause of the more frequent burstings. It is more probable that the greater frequency is due to the greater quantity of scale that is deposited in a given time when the boiler is driven at a high rate, and the conclusion to be drawn from this is that with high rates of evaporation it becomes necessary to use feed water that is purified before entering the boiler.

Wm. Kent.

New York.

Water-Hammer in Vacuum Pump

We had considerable trouble by vapor being carried over from the surface condenser to the vacuum pump and causing water-hammer. It was necessary to stop the pump

Reservoir for Condensate

and relieve the vacuum before the water would drain out, and as this usually occurred during the heavy-load period it called for fast work.

The quickest way was to slack off the valve-chest cover, but as the water accumulated to a dangerous extent, four or five times on a watch, it became a serious matter. To overcome this, I connected a 6-ft. length of 4-in. pipe, with a reducing elbow and a 1-in. globe valve at each end, to the bottom of the valve chest. Valve *A* at the end next to the pump should be left open and *B* at the other end closed until water accumulates in the pipe; then *A* is closed and *B* opened to drain the water into the sewer. Pet-cock *C* is opened to admit air during the draining process. With a reservoir of this capacity, it is only necessary to drain out once in twenty-four hours.

F. O'DONNELL.

Coscob, Conn.

Correction for Twisted Valve Stem

The diagram shown was taken from the high-pressure cylinder of a Corliss cross-compound condensing engine connected to a centrifugal pump. One valve stem was so twisted that the valve had a late admission, as shown, and the speed of the engine was reduced from 135 to 128 r.p.m.

After the key was taken out, the valve was turned until

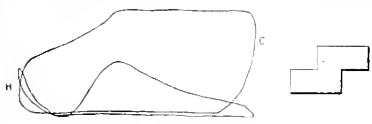


DIAGRAM WHEN STEM WAS TWISTED; NEW KEY

it was in the right position and an offset key was made to suit the new position instead of turning the stem over and cutting a new keyway. The valve required no further adjustment.

LAWRENCE KJERUIFF

Kansas City, Mo.

Improperly Finished Pumps

Referring to the letter on p. 892, Dec. 22 issue, under the above caption, I agree that stuffing-boxes are generally too shallow, but find that better results can be obtained with the bottom of the stuffing-box and the face of the gland square than at an angle. The packing should touch the rod from one end of the stuffing-box to the other with a moderate pressure over a large area rather than a concentrated pressure on a small area at the two ends, causing excessive local friction and wear.

I have designed and used many stuffing-boxes for steam, water and vacuum and have never had any difficulty with square faces. The operating engineer is quick to see the advantage of having each piece of packing in the box doing something like its share of the work. I have packed ½-in. reciprocating valve stems against 150-lb. pressure with soft packing in a stuffing-box 2½ in. deep. The glands were held by two ⅜-in. studs screwed up snugly with a small wrench, causing very little friction.

Good results have been obtained with a shallow stuffing-box having 30 deg. beveled bottom and gland face in packing a stationary pipe extending through a jacket against a steam pressure of 150 lb. In this case the stuffing-box was only 1 in. deep for ½-in. pipe, the object of the bevel being to obtain a tight joint in a small space regardless of friction.

E. P. HAINES.

Baltimore, Md.

Large Saving in Hotel La Salle Plant

To anyone not acquainted with the facts, the attempt on page 63 of Jan. 12 to refute the article appearing in the Nov. 3 issue of POWER might appear like an able defense of the former high cost of operation, but as a matter of fact it is misleading, to say the least. In the following reply it is the writer's intention to take each paragraph in turn and to give the facts in each case. Before doing this, I wish to state that the figures in Mr. Wilson's article are correct, and this statement is verified by the accompanying letter from the auditor of the hotel, who has held that position since February, 1910. The deductions made and the reasons given for the savings are also true in every respect. I know personally that it was not the author's intention to find fault in any way with my predecessor or his method of running the plant. There had been a difference in operating cost of $45,000 per year, and to tell how such an enormous saving had been made was the sole purpose of the article. This was done accurately. I do not take any glory unto myself for the saving, as in my opinion any engineer worthy of the name could have effected the same results by keeping on the job and by winning the full confidence of his men and his employer. Following is my reply, in which the numbered paragraphs refer to those of similar sequence in the preceding letter.

1. Mr. Lawrence admits that he was on the job 18 months before the hotel was opened. He had to pass on all the mechanical equipment before it was contracted for and also to O.K. the same before it was accepted. It was all contract work and all changes were up to the contractor. Certainly hotel help was not used to make contractor's changes. After the hotel opened all material and any labor done by the plant force which did not apply to the engineering department was charged to "Improvement and Betterments." The department was given credit and to the full amount specified by the engineer. Although Mr. Lawrence does not actually say that it was charged to his department, he infers that it was and overlooks the fact that the data given in the article do not go back of 1910. It will be seen in Table 2 of the article that the labor charges are practically the same for the four years given. The maintenance and supply items for 1910 and 1911 are excessive, due to lax operating methods, but the items are made up of legitimate power-plant charges.

2. By the present management it is also required that the house be thoroughly ventilated at all times, but as there were certain ventilating fans performing certain functions at different times, it was possible, by making a few changes, to arrange a schedule of fan operation which permitted shutting down some of the fans part of the time and the saving of considerable power. Under former conditions it was impossible to properly ventilate and cool one of the dining rooms until the air ducts had been enlarged and an additional fan installed, having a capacity of 6000 cu.ft. per min. During the summer months this room had been closed as it was so hot nobody could stay in it. For the past two years it has been open every day. Besides, a complete ventilating system has been installed in the laundry, where formerly there was no ventilation at all. All other fans are being run the same as ever, but only when needed and not haphazard as before. Instead of shutting down motors, except as before stated where they are run on schedule, three additional motors

have been installed in the laundry, two in the nineteenth-floor kitchen, one in the eighteenth-floor kitchen, and two in the sub-basement. Regarding cooling and refrigeration, a more even and lower temperature is maintained in the different rooms than ever before, and an additional 6000 cu.ft. of air per min. is supplied. This is not cutting down on service. The figures in the article also show that considerably more ice was made. The machines are now operated on exhaust steam and not on live steam, as in former days. This is an item of saving. It is true that 25-watt tungsten lamps have been substituted in part for 16-cp. carbon lights. Any intelligent engineer would do the same, and it is inconceivable that any manager would refuse a better light costing less for maintenance and current providing he was properly informed of the facts.

3. The steam traps certainly did have an elaborate system of piping and must have been put in on the time and material basis. There were 15 on the high-pressure lines in the engine and boiler rooms. On the discharge line of each trap was a valve and between this valve and the trap a 1/4-in. valve for detecting leakage of steam. Upon taking charge, I went to each trap, closed the valve in the discharge line and opened the try-valve. Without any exception, not water but steam under boiler pressure blew out. An investigation showed that the seats and valves of the traps were badly worn, and in some cases the valve was completely eaten away, giving a direct passage for the steam. The traps discharged to an open heater with cast-iron sections, and this in turn was connected with the expansion tank, from which risers to the heating system and the atmospheric exhaust were taken off. An employee who has been under both managements reports that on one occasion a repair was to be made to the heater. The valve between the expansion tank and the heater had been closed. Shortly afterward the latter exploded, and the cause was live steam from the traps.

4. It is common knowledge that as a hotel or any building gets older it requires more attention and especially more sweeping. This is true in the present case, and the hotel is noted for its cleanliness. As stated, there are three vacuum machines of the inspirator type which use steam at boiler pressure and carry a vacuum of 12 in. On each machine is a control valve to automatically shut off the steam when the proper vacuum is reached. When the writer took charge all three machines were in operation and blowing continually without a sign of cut-off. The machines were overhauled, and it was found that one would do the work and still cut off intermittently. The same number of sweepers are in operation, and, as the hotel is getting older, more sweeping is necessary. One machine does the work very efficiently.

5. These lights were installed during the summer before the writer took charge, for illumination during the roof-garden season. The same number of lights are still there and are burning every night of the season. There is no change in the schedule. Instead of reducing the lighting it has been increased. An addition of 825 twenty-five-watt tungsten border lights has been made at the fourth floor, also 1350 ten-watt lamps in a large roof sign, and numerous table fixtures, each containing three 10-watt tungstens.

6. Changes are continually being made, and more now than when I first took charge. The nineteenth-floor kitchen has been entirely remodeled and several additional steam-using appliances installed. A new kitchen has also gone in on the eighteenth floor, with coffee urns, soup heaters, steam tables, etc. Besides, a number of steam-using appliances have been added to the laundry. All of this work was done by the engineering department. Contrary to the inference made by Mr. Lawrence, the work was charged to "Improvement and Betterments" and the power plant was allowed a credit.

7. All engineers in Chicago know what it was to get coal in 1910, but that was only during the months of June, July and August. At that time I was in charge of a hotel plant three times the size of this plant and made a better showing than in the previous years. In Table 2 in the article the difference in the coal bills for 1910 and 1911 is $3500, which, divided by the tonnage for the year, amounts to only a few cents. Under conditions as I found them here, it was impossible to burn anything but a good grade of washed coal, as with inferior coal the combustible matter in the ash would be excessive. As to records, the boiler-room foreman who was on the job then and is still in the same capacity states that no records of coal were kept other than the amount of coal coming into the building; also that the water meter was out of repair continuously and was inaccurate, and before it could be used on the tests cited it had to be completely overhauled. Readings from it could not have been "absolutely correct," and it is rather difficult to see how the daily coal consumption could even be estimated with any degree of accuracy. Steam coming from the exhaust head on the La Salle, even on the coldest days, was a matter of comment among engineers of the city. Besides it is difficult to see how evaporation could be "kept up to the highest possible point at all times" with a CO_2 reading of 1½ to 2 per cent., which is all that could be obtained by the writer until the furnace conditions were changed.

8. To operate the electrical units at the best load factor, the same means were at the disposal of my predecessor. Even with the larger load he was carrying, due to inefficiency in more ways than one, it would not have been necessary to operate more than one unit at a time. In the very tests to which he refers a change of schedule was recommended, which would have effected a saving estimated at $15 per day, or $5475 per year. The two methods of operation were outlined in the article. I have followed the plan of operating the second unit from 7 a.m. to 5 p.m., the largest unit from 5 p.m. to 1 a.m., and the smallest the balance of the night. This allows each unit to operate at its highest efficiency and has proved a very flexible arrangement. All of the rooms are still cooled in the summer, as previously stated. Furthermore, hourly temperature readings are taken. By supplying an additional 6000 cu.ft. of air per min., it was possible to reopen the German restaurant during the hot months. This does not look like a discontinuance of service. The various services required have been maintained, but much more efficiently than in the past. As to the plant speaking for itself, I am willing to have it. I do not consider an engine room served by fluttering arc lamps well lighted. It now has clusters of 25-watt tungstens. All pipe joints and valve stems are kept packed and steam tight. When the writer took charge, there were leaks in the headers, stop valves, auxiliary valves, etc. In fact, on top of the boilers conversation was impossible, and in any part of the plant it could only be carried on under difficulties. The boiler tubes were in bad condition and a large number had

to be replaced. Water leaking at the ends of the fire tubes had mixed with soot and formed a hard deposit, half filling the tubes for a considerable portion of their length. The remodeling of the furnaces was accurately described in the article. Due to this it was possible to use an inferior coal costing less per ton. As to the condition of the engines, the following sentence of a letter from the builders to the writer will be illuminating: "I want to congratulate you on the nice running of your engines, which have undoubtedly taken time and great care to bring into line, as they have been fearfully abused."

9. Mr. Lawrence could not be expected to know that reliable tests have been conducted by the writer so that he knows exactly what he is doing in the plant and furthermore that accurate daily records are kept of coal and water. As to the tests mentioned by Mr. Lawrence and printed in part in his letter, I have nothing to say. There is no occasion to bring another party into the controversy, and for that matter it is not necessary, as the results obtained speak for themselves. These were given accurately in the article by Mr. Wilson, as well as a careful analysis of how the saving was effected.

10. In the article appearing in the Nov. 3 issue, the size of the new elevator pump was given, but no special reference was made to it as it was not installed until last August. The latest records given in the article were for the year 1913. As to the necessity of installing this pump, it may be stated that the three pumps originally installed had to be maintained in service from 6 a.m. to 12 midnight, and at times under the former management they were so hard pressed that it was a common occurrence for the accumulator to hit the bottom, nearly wrecking the duplex pumps before the attendants could reach the throttle. Apart from better elevator service, the new pump has effected a saving in coal, as the coal costs for corresponding months in 1913 and 1914 will show:

COAL COST PER MONTH

	1913	1914
August	$3159.09	$3059.10
September	3198.62	3046.52
October	3471.41	3128.93
November	3229.66	2898.28

In August the pump was only run two weeks, as the builders still had some work to do on it. In September and October, it was run three weeks each month and in November nearly four weeks.

The new hot-water heater was badly needed. Before it was installed, it was necessary to carry 3 to 4 lb. back pressure on the entire system to furnish enough hot water for bathing, and even then there were many complaints over the low temperature of the water. The new heater has done away with this trouble, and the building can be heated by steam under a pressure of 1 lb.

The above covers all points brought up by Mr. Lawrence. Numerous other items might be mentioned to show how the saving given in the article was effected, and if desired the writer can go into fuller detail at a future date. It will be of interest to notice in the auditor's letter that the saving last year was even greater than in 1913, and more work has been done than ever before.

W. W. Bird,
Chief Engineer, Hotel La Salle.

Chicago, Ill.

I have served the Hotel La Salle Co. in the capacity of auditor since February, 1910, and to the best of my knowledge the charges made to the engineer's department during the periods shown in Table 2 of the Nov. 3 issue of Power were all legitimate charges to that department.

When the services of the engineer's department have been required for changes or additions to construction, full credit has been given on the company's books for time and materials used.

It should be noted that your correspondent particularly refers to the period of September to December, 1909, whereas the Nov. 3 issue of Power gives no figures whatever for that period. It may be that he has some specific item in mind, and if such is the case, I would be glad to investigate and report on it after hearing from him.

It might interest your readers to know that further economies effected in the engineer's department during the year 1914 make a still more favorable comparison with previous years' operations, especially in view of the continued increase in the hotel's business.

W. H. Peterken,
Auditor, Hotel La Salle.

Chicago, Ill.

Detecting Ammonia Leaks

In the Dec. 15 issue, Mr. Anderson takes exception to my method (see Nov. 3 issue, p. 656, under Robert G. Thurston) of detecting ammonia leaks in brine tanks. His method is to empty the tank, get inside it and test the coils with a sulphur stick while the pressure is on the coils. This is the best method, but how many engineers are going to take the trouble to pump out the tank, crawl inside of it while it is cold and slimy and conscientiously apply the sulphur stick to every joint? There are few. I agree with Mr. Anderson that there will be a few pounds of ammonia lost by using my method, also that the sulphur stick will locate ammonia leaks more readily than litmus paper or Nessler's solution, but when he claims that he can detect ammonia in brine by smell before it can be detected with litmus paper or the solution, I must say I am skeptical.

Mr. Anderson states that to test the brine-tank coils properly one should reduce the pressure to 5 lb. before testing. The higher the pressure the more prominent the leak and the more readily it may be detected.

The use of the words "discharge tanks" in my article is wrong. The manuscript read "discharge lines."

Mr. Anderson claims that some losses are due to the disintegration of the ammonia. This is questionable.

Water should not be present in the ammonia in a properly managed compression plant. In an absorption plant it is of course different. Many operators claim that running with cold rods draws moisture into the cylinder with each stroke of the machine, due to the moisture clinging to the cold rod and being drawn in with it. I have seen considerable water get into the system with the oil by using the oil over again and not having it properly filtered. Moisture will also get into the system when the expansion coil or suction line is opened and left open; the moisture precipitates on the cold surfaces and accumulates in the pipes and when the system is put in operation again is swept along with the ammonia.

If steam is used to clean the oil out of the system and it is not thoroughly blown out with air afterward, the condensation will remain in the pipes.

Thomas G. Thurston.

Chicago, Ill.

Inquiries of General Interest

Inspection of Storage Batteries—How often should storage batteries be inspected?

C. E. C.

It is well to thoroughly inspect them at least once a week, using a special lamp for the purpose.

Bar-to-Bar Test of Armature—When making a bar-to-bar test of a dynamo or motor, what would a sudden drop of milli-volt reading indicate?

Z. H.

A sudden drop in the reading would indicate a short circuit, either between the bars themselves or between the windings connected to the respective bars.

Pitting Due to Presence of Fatty Acids—What would cause oily feed water returned from an exhaust steam-heating system to pit boiler tubes?

R. M. C.

Pitting might be due to fatty acids contained in animal or vegetable oil used as an adulterant of the engine cylinder oil.

Anchor Ice—What is anchor ice and how is it formed?

R. C. M.

Anchor ice or ground ice consists of needles and thin scales of ice which form in moving water and sometimes on the bottom of still water. They usually cease to form after the body of water has become frozen over. On coming in contact with submerged objects these particles of ice adhere and soon form large masses difficult to dislodge.

Quality of Steam Gathered near the Surface of the Water—What would be the quality of steam gathered in a petticoat pipe near the surface of the water in a boiler as compared with steam taken from the top of the boiler?

J. E. N.

In the process of ebullition the globules of steam, in rising from the body of water to the surface, entrain water which is unevaporated and which is projected above the surface of the main body of water. Unless the steam is superheated there will generally be some water thus entrained that will be carried to every part of the steam space of the boiler. It is usually the case that the nearer the disengaging surface of the water, the larger will be the proportion of water thus entrained by the steam, hence steam gathered near the surface of the water by a petticoat pipe would be much wetter than steam taken from the top of the boiler.

Changing Governor Pulley—A belt-driven governor regulates the speed of an engine to 80 r.p.m. The governor driving pulley on the main shaft is 12 in. diameter and the receiving pulley on the governor is 7 in. diameter. To what size should the governor receiving pulley be increased to regulate the engine to 90 r.p.m.?

With 80 r.p.m. of the engine the speed of the governor pulley is $\frac{80 \times 12}{7}$ r.p.m., and as practically the same speed of governor would be required, then for regulation at 90 r.p.m. of the engine shaft, the governor receiving pulley should be

$$(90 \times 12) \div \left(\frac{80 \times 12}{7}\right) \text{ or } 7\tfrac{7}{8} \text{ in. diameter.}$$

Original Babbitt Metal—What was the original recipe for babbitt metal?

L. J.

The original recipe proposed by the inventor, Isaac Babbitt, a brass founder, of Boston, Mass., was 4 lb. of copper, 8 lb. of antimony and 24 lb. of tin = 36 lb. of mixture called hardening, and to every pound of hardening 2 lb. of tin was added, so that the completed mixture was in the proportions: 4 lb. of copper, 8 lb. of antimony and 96 lb. of Banca tin or 1 : 2 : 24. For making the alloy the melting must be gradual or the antimony and tin will largely separate from the copper and form oxides or dross on the surface. Thus 4 lb. of copper is melted first, then 12 lb. of tin and 8 lb. regulus of antimony are added slowly to the molten copper, to which 12 lb. more of tin is added to form the hardening. Then for use with each pound of this, 2 lb. of Banca tin is melted. The surface should be covered with pulverized charcoal and a small portion of sal ammoniac. Previous to pouring the mixture it should be well stirred.

Evaporation per Pound of Fuel Oil—What would be the rate of evaporation per pound of fuel oil having a calorific value of 18,500 B.t.u. per pound with a boiler efficiency of 75 per cent., a steam pressure of 50 lb. gage and a feed-water temperature of 135 deg. F.?

S. F.

With 75 per cent. boiler efficiency there would be

$$0.75 \times 18{,}500 = 13{,}875 \text{ B.t.u.}$$

realized per pound of fuel. As each pound of feed water raised to 50 lb. gage pressure, or about 65 lb. abs., would contain 1178.5 B.t.u. above 32 deg. F., and as with feed water at 135 deg. F., or 135 — 32 = 103 deg. F. above 32 deg. F., each pound would receive 1178.5 — 103 = 1075.5 B.t.u., then $\frac{13{,}875}{1075.5}$ or 12.9 lb. of water would be evaporated per pound of fuel.

Effect of Temperature on Wire Resistance—If the resistance of 1000 ft. of copper wire at 75 deg. F. is 100 ohms, what would be the resistance per foot at 90 deg. F.?

R. J.

The resistance of copper wire increases with an increased temperature. The formula to be employed is:

$$R_2 = R_1 + C \times R_1 (T_2 - T_1),$$

where

R_2 = The resistance, hot;
R_1 = The resistance, cold;
C = The temperature coefficient, depending upon the metal, which in the case of annealed copper averages about 0.00223;
T_1 = Temperature, cold;
T_2 = Temperature, hot.

Hence, where the resistance of 1000 ft. of copper wire at 75 deg. is 100 ohms, the resistance per foot at 90 deg. F. would be

$$R_2 = 100 + 0.00223 \times 100 \ (90 - 75)$$
$$= 100 + 0.223 \times 15$$
$$= 103.345 \text{ per 1000 ft. or 0.103345 ohms per ft.}$$

Connecting Ground Circuit of Generator—At what point in the armature of a three-phase generator would it be proper to connect the ground circuit for the generator to operate on a grounded neutral system?

A. R. P.

If the generator is star connected, ground the neutral as in Fig. 1, in which case the maximum potential to ground will be 58 per cent. of the line voltage. If delta-connected,

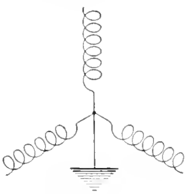


Fig. 1

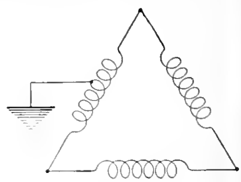


Fig. 2

Methods of Grounding Generator

one side may be grounded as in Fig. 2, in which case the maximum potential to ground is 87 per cent. of the line voltage. The ground may be direct, or through resistance or reactance, the latter limiting the flow of current.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

The Conversion of Energy

All the activities of power plants depend upon the general fact or law of nature that the different kinds of energy can be converted one into another. In these activities four kinds of energy are involved: Chemical, thermal, mechanical and electrical. Selection by twos gives the following combinations, as illustrated by one or more practical examples:

Chemical energy to heat: Combustion in boiler furnace or in engine cylinder (a).

Chemical to mechanical: No direct conversion, heat energy coming between.

Chemical to electrical: Electric battery, particularly the storage battery (b).

Heat to chemical energy: Dissociation of water or carbon dioxide in boiler furnace or gas producer, also operations of reducing metals from their ores (b) or (c).

Heat to mechanical work: All kinds of heat engines (c).

Heat to electricity: Only such feeble activity as that of the thermocouple.

Mechanical work to chemical energy: None.

Mechanical to heat: Compression, friction, impact, etc. (a).

Mechanical to electrical: The electric generator (b).

Electrical to chemical: Electrolysis, as in charging storage batteries (b).

Electrical to heat: Electric lighting and heating; use of a rheostat as load for a generator, when testing (a).

Electrical to mechanical: The electric motor (b).

Three of these combinations, namely, chemical to mechanical, mechanical to chemical, heat to electrical, are either absolutely or practically impossible except through some intermediate transformation. The other nine are divided into three classes, indicated by the letters (a), (b), (c).

Class (a) comprises the transformations which are or can be complete, every one having heat as its final state. The fact that the whole of the fuel may not be burned in a furnace or engine does not qualify the completeness of energy conversion for what is burned, and under special conditions, as in the fuel calorimeter, complete combustion is surely obtained. In the conversion of other forms of energy into heat an efficiency of unity is, therefore, attainable.

The transformations in class (b) have unit efficiency as an ideal limit, which may be approached but never quite attained. To these interchanges between chemical and electrical and between mechanical and electrical energies should be added the transmission of mechanical work and its change in form by machinery. The efficiency of most machines lies within the range of from 70 to 95 per cent. A large generator or motor will go a little above 95 per cent. The perfect generator, motor or storage battery cannot be realized, but it is easily imaginable and can be quite closely approximated.

Notice particularly that all the energy not usefully converted in the operations of class (b) is changed into heat and thus wasted.

Last comes class (c)—the conversion of heat into some other form of energy, and especially into mechanical work; in other words, the question of heat-engine operation and efficiency. The outstanding fact in this field is the impossibility of anything approaching complete conversion. Within the limits imposed by natural physical conditions, there is no known or imaginable method or scheme of working by which a heat engine can change into work the whole of a given amount of heat supplied to it. Necessarily, such an engine converts but a portion of the heat received and gives up the remainder as heat in an inconvertible state. Its limit of efficiency is not 100 per cent., but some fraction which, with varying conditions, ranges from perhaps 15 to 65 per cent. To reason out the character of this limit and establish its value is one of the important tasks of the science of thermodynamics.

After the descriptive statements which have just been made, and keeping in mind the power-plant point of view, the following summary will appear rational:

Chemical, mechanical and electrical energies may be put in one class, and are sometimes called the higher energies. Heat is a class by itself and is a lower form of energy, especially when it has sunk into a state of low temperature or intensity.

Then the different types of conversion classified as (a), (b) and (c) may be briefly defined as follows:

The higher energies can be completely converted into heat. They also have certain interconvertibilities, in which the efficiency may approach, but can never attain to, unit value. And what is not usefully converted is lost as heat.

By certain processes heat can be converted into the higher energies, but only in part, since there is always a large remainder of energy left in thermal form.

Finally, the tendency in nature is for all kinds of energy to sink into the form of heat of low temperature.

Relative Efficiency of Steam, Gas and Oil Engines—Roughly stated, a first-class modern steam engine utilizes about 12 per cent. of the available heat in the coal, resulting in, say 1.6 to 1.7 lb. of fuel per b.hp.hr. during a week's work of 55 hr. If the boilers are to be fired by producer gas, for which purpose slack and dust can be used, then each brake horsepower will require about 2 to 2.2 lb. of coal. Internally fired gas and oil engines are approximately twice as efficient as steam engines, which means that they utilize about 25 per cent. of the available heat. Crude oil being 37 per cent. better than good ordinary coal, oil engines should use only about three-eights as much oil as the coal mentioned above, say about 0.6 lb. per b.hp.-hr. Then, however, as there are no boiler radiation losses over night, a material saving results and the oil consumption per week of 55 hr. may be about 0.5 lb. per b.hp.-hr. Petrol and similar internal combustion engines would require about 0.4 lb. per b.hp.-hr. Gas engines have also about the same efficiency as oil engines; but as there is a loss of about 20 per cent. in the producers, if these work day and night, and another loss of quite 10 per cent. if they have to stand idle over night, the efficiency of gas engines is only about 40 per cent. better than that of first-class steam engines.

Design and Operation of the Cleveland Municipal Electric Light Plant*

By Frederick W. Ballard

The new Cleveland, Ohio, municipal lighting plant, known as the East 53d Street Station, went into operation July 20, 1914. It is the largest central station in this country built by a municipality, and is intended not only to supply electric current for street and commercial lighting, but also for power users. The rates charged for the service range from $0.03 per kw.-hr. maximum to $0.01 per kw.-hr. minimum. This station has a capacity of 25,000 kw. and is at present loaded to one-fifth of its capacity.

The estimated results which will be secured from the new 25,000-kw. station, which has just been placed in operation, are based upon an annual output of 60,000,000 kw-hr. and with fixed charges founded upon a total plant investment of $3,000,000. Fixed charges amounting to 9 per cent. on this investment would equal $0.0045 per kw.-hr. Cost for coal is estimated at $0.002 per kw.-hr.; station costs exclusive of coal at $0.0015; distribution costs exclusive of fixed charges at $0.004; administration charges at $0.005, and profits at 8 per cent. on the investment at $0.004. This makes an average price to be secured per kilowatt-hour generated of $0.0165. From the three months' operation of this station, together with tests that have been conducted, the indications are that these estimated results will be secured.

The plant was built from the proceeds of a $2,000,000 bond issue by the City of Cleveland, about one-half of this amount being invested in the station itself. The other half is to be invested in the substations and in the distribution system, including overhead and underground lines. In addition to the $2,000,000 derived from this bond issue, there are also available the proceeds of a $500,000 bond issue voted by the City Council to supplement the original bond issue, making a total amount of $1,500,000 to be invested in the distribution system. The value of the present distribution systems connected with the Brooklyn and the Collinwood stations is about $500,000, making the total value of the East 53d Street Station, together with its distribution system, about $3,000,000.

The results which have already been obtained in the operation of the Brooklyn lighting station and the East 53d Street Station during the first eight months of the year 1914 tend to substantiate the original estimates of what will eventually be secured in connection with the operation of the East 53d Street Station. A statement of revenue and expense connected with the operation of these two stations for the first eight months of the year is as follows:

TABLE 1—REVENUE AND EXPENSE STATEMENT FOR FIRST EIGHT MONTHS, 1914

Revenue from sale of current for first eight months of 1914	$153,363.65
Kw.-hr. generated, 7,863,610; average sale price, $0.0195.	
Kw.-hr. sold, 6,270,726; average sale price, $0.0244.	
Operating and maintenance for first eight months	97,044.60
Kw.-hr. generated, 7,863,610; average cost price, $0.0123.	
Kw.-hr sold, 6,270,726; average cost price, $0.0154.	
Net earnings for eight months	$56,319.05

The total kilowatt-hours generated for eight months is greater than the output for the year 1913. The average cost price per kilowatt-hour generated is $0.0123, as compared with $0.0149 for the previous year. The results secured in the way of operation and maintenance costs in the power station itself for the months of August and September are shown in Table 2:

TABLE 2—EAST 53D STREET POWER STATION REPORT, AUGUST AND SEPTEMBER, 1914

	Aug.	Unit Cost	Sept.	Unit Cost
Operation				
Labor	$1498.48	$0.0018	$1573.00	$0.0017
Switchboard attendance	352.80	0.0004	380.00	0.00042
Oil, packing and waste	....	.....	66.89	0.00008
Sundry expense	....	.....	10.46	
Coal	2686.50	0.0033	2415.69	0.0026
Maintenance—				
Condensers, piping, etc.	5.48	.....	.....	.....
Total operation and maintenance	$4543.26	$0.0056	$4446.04	$0.0048
Total kw.-hr. generated	809,120	.....	914,850	.....

*Excerpts from paper read at the annual meeting, December, 1914, in New York City, of the American Society of Mechanical Engineers.

The East 53d Street Station during these two months has been operating at less than one-fifth of its total capacity. The figures representing unit costs for the various items of labor, maintenance, fuel, etc., are considerably higher than should obtain when the station is running up to its capacity, when it will be operating at a much higher efficiency in regard to coal consumption per kilowatt-hour, and also the labor and other charges will be less per unit cost by reason of the larger output. During the month of August, the output of the Brooklyn and East 53d Street Stations amounted to 1,117,920 kw.-hr., of which 936,467 kw.-hr. was sold to customers, giving a loss in transmission of only 16¼ per cent. The average sale price for the kilowatt-hour generated was $0.0174, while the average sale price of what was sold was $0.0207, the revenue for the month being $19,405.38.

That an average load factor of 40 per cent. will be secured on this station when the load is built up to its ultimate capacity seems to be assured, and the indications are that a better load factor will be obtained. A typical load curve is only 2700 kw., but with a load factor of 80 per cent. based on the peak load there is a total output on the generating station of 51,925 kw.-hr. If these conditions can be maintained or even approximated when the load on the station has been built up to its ultimate capacity, the load factor will be considerably greater than 40 per cent. The location of the station was determined mainly by the convenient and economical facilities for delivering coal and also by the possibility of securing the cheapest and best water for condensing purposes. The Water-Works Department has a 9-ft. tunnel extending five miles into Lake Erie and draws water at this point from 125 ft. below the surface. This water, after passing through the surface condensers in the power plant, passes on to the suction chambers of the water-works pumping engines. The increase in temperature of the water going into the city mains, it is estimated, will not exceed 1 deg. F. In this way the lighting plant has not only secured the cleanest and coldest water for condensing purposes possible, but has also made use of a plant calculated to obviate any possibility of interruption by clogging of the inlet with ice or débris floating in the lake.

The coal question was considered as of next if not of equal importance to that of water. As the Lake Shore & Michigan Southern Ry. tracks run along the southern line of the property, with an elevation of about 60 ft. above the lake level, a method of handling the coal almost entirely by gravity has been worked out. Fig. 1 is a cross-section of the station in detail, wherein the coal is delivered overhead by the railway cars and is discharged by gravity into 3400-ton capacity bunkers, from which it is drawn through gates under pneumatic control into an electric telpher, which moves back and forth from under the bunkers on the track leading out over the stoker hoppers. The coal hopper on this telpher is carried on scale beams, and the weight of the coal and the time of delivery are recorded.

The special features in connection with the design of this station different from standard practice are as follows: The use of motor-driven auxiliaries throughout the plant; large boiler units with high steam pressure; economizers of greater capacity than ordinarily installed; a new arrangement of coal-handling apparatus; the use of both forced and induced draft with practically atmospheric pressure in the combustion chamber; automatic control of furnace conditions; simplicity of the piping layout, due to motor-driven auxiliaries; and the use of an auxiliary steam turbine for driving the auxiliary motors. This turbine is supplied with a jet condenser, the cooling water for which is used as boiler feed water after being passed through the economizers.

The practice of using motor-driven auxiliaries has not been adopted in this country principally for two reasons—(a) the use of exhaust steam from the steam-driven auxiliaries for feed-water heaters has been considered advisable as giving sufficient economy to warrant the use of steam, rather than motor-driven auxiliaries, and (b) the operation of the auxiliary equipment in the station by current from the main generators has been considered to introduce an element of uncertainty and unreliability into the service which it would be better to avoid.

To the first objection it can be stated that the thermal efficiency of the station can be shown to be higher when the

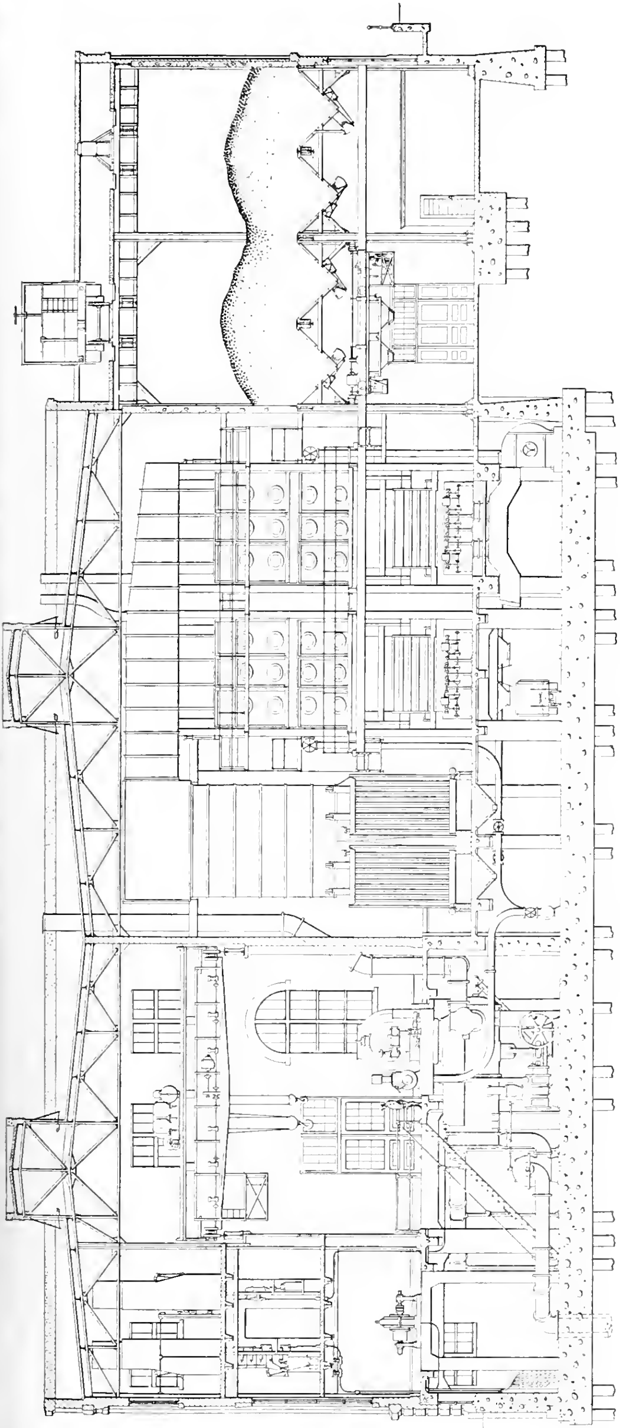


Fig. 1. Cross-Section of the Cleveland Municipal Lighting Plant

auxiliaries are motor driven and the heat for the boiler feed water is secured by the use of economizers from the flue gases. No arrangement of steam-driven auxiliaries would give just the proper amount of exhaust steam for heating the feed water properly at all loads on the station. There would always be periods when there would be either not enough or too much steam, and some would go to waste. There is also the complexity of steam piping necessary for supplying the auxiliary engines, with the incident losses from radiation and leakage. The second objection is answered by the installation of an auxiliary steam turbine. A 1000-kw. turbine with an overload capacity of 1500 kw. has been in operation in the Brooklyn Station for years and is now in good condition. This machine will be removed to the new station.

This machine will be operated in connection with a jet condenser, the cooling water for which will be drawn from a cistern which is used for the storage of the boiler feed water for the station. This cistern is divided into two compartments by a wall, the top of which is about two feet below the surface of the water. On one side of this wall will be the cold well and on the other side the hotwell. The condensate from the three main turbines will be discharged into the cold well and carried to a point near the bottom, where is located the suction end of a pipe carrying the circulating water to the jet condenser. The discharge from the jet condenser will be carried to the other side of the cistern, or the hotwell, and delivered at a point near the suction end of the pipe carrying feed water to the boilers. The makeup water for the system will be delivered into the cold well at the same point as the discharge of the condensate from the main turbines. The makeup water will be under control of a float valve designed to maintain the level of the water in the cistern at the required height.

It is not the intention that the quantity of water flowing through the feed piping system to the boilers shall determine the volume passing through the jet condenser as the volume of circulating water will be several times greater than the quantity of feed required by the boilers. The water in the cistern will, therefore, pass through the jet condenser several times before it goes as feed water to the boilers, and to prevent a uniform temperature throughout the cistern and a consequent lower vacuum in the jet condenser, the arrangement of hotwell and cold well was provided, and the piping was connected in such a manner as would supply the coldest water to the condenser and the hottest water to the boiler-feed system.

The auxiliary motors in the station will all be connected through a double bus system, so that each motor can be operated either by current from the auxiliary turbine or from the main generator. In this way the load on the auxiliary turbine can be adjusted so that the temperature of the feed water will be that best suited for delivery to the economizers. This temperature should be approximately 120 deg. F. If much less than this amount, the economizer tubes will scale with soot and cause trouble. If a greater temperature than that necessary to avoid this trouble is secured, there will be a sacrifice of economizer efficiency. Fig. 2 is a floor plan of the plant.

The use of large boiler units with high steam pressure was decided upon. The boilers ultimately installed were similar to those in the Delray Station in Detroit, and the dimensions are identical, except as to the length of the drums. These boilers (Fig. 3) each have 10,000 sq.ft. of heating surface and are designed to carry 275-lb. working pressure with a superheat ranging from 125 to 150 deg. F. They are equipped with underfeed stokers and are intended to be capable of operating up to 300 per cent. of rating.

The operation of the boilers at a high percentage of rating means a higher temperature of flue gases. This, with the low temperature of feed water, gives a temperature head between flue gases and feed water which will be practically double that ordinarily obtained in economizer practice. This alone would be sufficient to warrant a larger amount of economizer heating surface than would ordinarily be deemed advisable. However, there is another factor in the Cleveland situation which also warrants an increase in the economizer capacity. In economizer practice, the interest on the investment, generally figured at 6 per cent., is balanced against the saving which will be produced in the economizers, but in municipal engineering it is found that interest on the investment can be figured at 4½ per cent. instead of at 6 per cent. This fact alone would warrant an increased capacity in the economizer. Taking these factors into consideration, it was thought that a conservative estimate on economizer requirements would be 27,000 sq.ft. of heating surface. They are arranged in two parallel sections, independently, so that either section can be cut out by means of dampers for cleaning and repairing, leaving the other in operation.

The use of both forced and induced draft contributes to the flexibility of the installation and makes it possible to carry practically a balanced pressure in the combustion chamber, thus avoiding one of the greatest sources of loss in boiler practice, the leakage of air through the boiler settings. Two induced draft fans were put in, either of which has a capacity for taking care of the peak load requirements of the station. A separate forced-draft fan with an individual motor drive was placed in the boiler room basement for each furnace. The motors on the forced-draft fans are under automatic control, and their speed is governed by means of rheostats controlled by the boiler pressure. The motors for operating the stoker feed are also controlled by rheostats governed from the pressure in the air ducts underneath the boilers. The induced-draft fans are under manual control, and their speed is intended to be regulated by the man operating the boilers so as to give the proper draft for holding practically an atmospheric pressure in the furnaces.

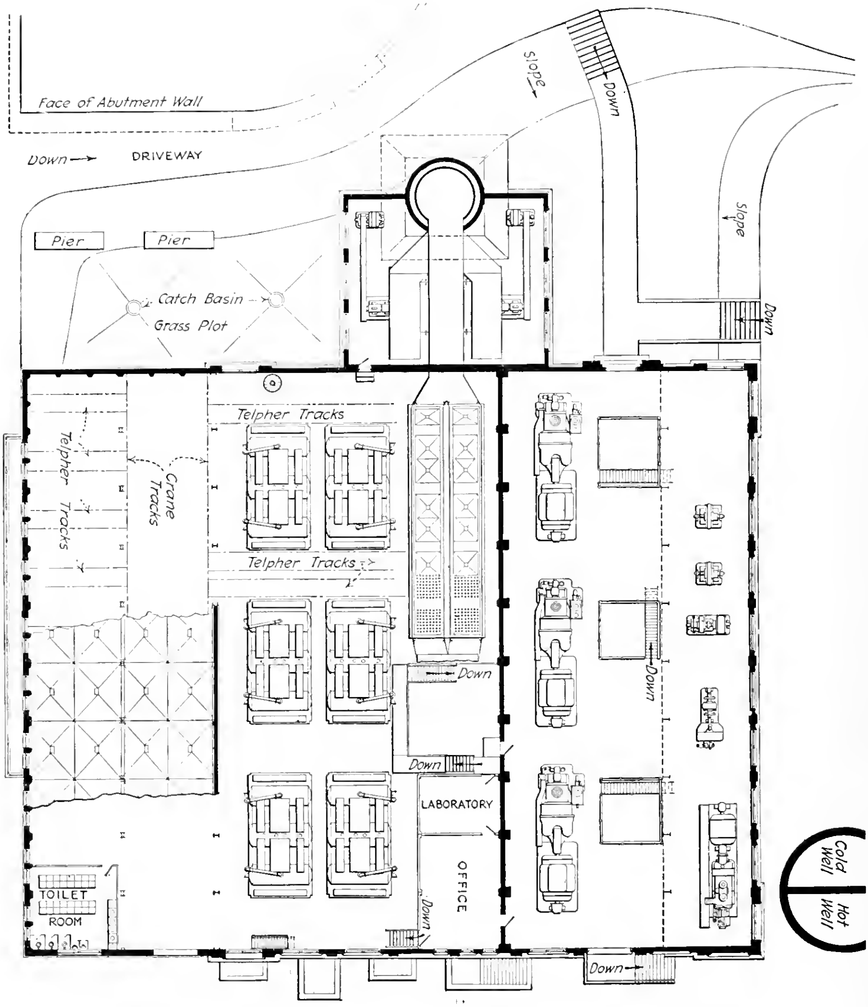


FIG. 2. FLOOR PLAN OF THE CLEVELAND MUNICIPAL LIGHTING PLANT

The steam piping is simple, because, outside of the auxiliary turbine and the emergency equipment consisting of a steam-turbine exciter and a turbine-driven feed pump, steam will be used only in the main generators. The plant is so arranged that each battery of two boilers is opposite one turbine generator, the steam lines from the boiler going to the header, from which a short branch is taken to the turbine. The header is capable of being cut into three sections by means of Hopkinson-Ferranti valves, with operative working parts of half the diameter of the steam main. The interior of these valves is shaped like a Venturi nozzle; they will pass an amount of steam equal to the full carrying capacity of the pipe with practically no reduction in pressure. The main steam header is located in the boiler-room basement near the floor, and the piping is arranged so as to drain to this header from all directions. This header is 135 ft. long and designed for the minimum of expansion which would effect a lateral movement in the branch pipes. It is divided in the middle by an expansion bend, which consists of two short headers carrying four small U-shaped pipes of only one-half the diameter of the main. Two halves of the main header are then anchored securely at their central points and carried on rollers from this point in both directions. This then divides the main header in such a way that at no place would the movement caused by expansion be more than that due to the expansion in one-fourth of its length. The main steam header is only 14 in. in diameter and is composed of ⅝-in. thick steel pipe with welded necks and flanges. The branch pipes contain no fittings except the valves, which are of heavy cast steel. All turns are of long bends and all sections have welded flanges.

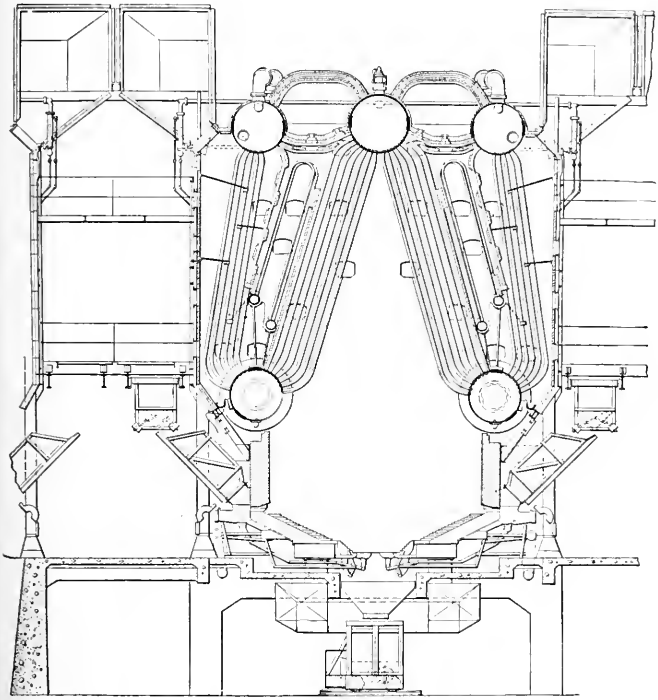


FIG. 3. SECTION THROUGH ONE OF THE BOILERS HAVING 10,000 SQ.FT. OF HEATING SURFACE

The feed-water pumps are all centrifugal. Two are constant speed and motor driven. One is steam-turbine driven and is designed for emergency purposes and for operation when no electric current is available. This pump is arranged with governor control for constant pressure and is therefore capable of being used in connection with either of the motor-driven pumps and to supply water to the boilers only when the demands are in excess of the capacity of the other pump.

In the chief engineer's office are located indicating and recording instruments for practically every operation in the station. There is a graphic recording totalizing watt-meter which gives a continuous record of the combined output of the station. The amount of feed water going to the boilers is shown by the indicating dial of a V-notch recorder, which also gives a continuous graphic record and the total quantity by means of integrating dials. The CO_2 in the flue gases is recorded, and recording thermometers keep record of the temperature of the feed water entering and leaving the economizer and the temperature of the flue gases in the boiler breechings as well as at the discharge end of the economizer. The steam pressure and the temperature of the steam in the main header are also recorded, thus giving a record of the superheat. This information, together with the record of the weight of coal going to each boiler, which is turned in to the chief engineer at the end of each 8-hr. shift, enables him to have a complete log of the performance of the station made up every day.

The use of 11,000 volts removes the necessity of having rotary converters, the absence of which is particularly notable when compared with the prevailing practice of supplying the congested districts of large cities from numerous substations in which there are placed rotary converters for changing alternating into direct current.

DISCUSSION FOLLOWING THE PRESENTATION OF MR. BALLARD'S PAPER

Robert L. Brunet, of Providence, R. I., in a written discussion, said that with low rates for energy the load factor of 40 per cent. would possibly be realized based on a peak of 18,000 kw., but when the peak of 18,000 kw. is reached the generating equipment will undoubtedly have to be increased to insure reliability and continuity of service. He has found that the income per $1 of investment varies from 20 per cent. to 25 per cent. in most private plants, while Mr. Ballard has estimated an income of 33 per cent. per $1 of the investment.

James R. Cravath, of Chicago, said that it would have to be demonstrated whether the estimated maximum load of 18,000 kw. could be brought to the Cleveland station with a distribution cost low enough to bring the total investment in power-plant and distribution systems to but $3,000,000. It is possible by cultivating the large motor-service business and ignoring the low-load-factor lighting business, such as residences and early-closing stores, that a 40 per cent. load factor might be maintained from the start. The natural tendency of rates as low as those given would be to load up the plant with low-load-factor business unless care was exercised to prevent it.

Alex Dow, president of the Detroit Edison Co., said that he had followed the construction and operation of the plant with interest; that the plant was a good one, a credit to Mr. Ballard, to the consulting engineer and to the city officers who let them go ahead and make a good plant. He said that what Mr. Ballard needed first was a distributing system, which he has not, and, second, a load, which he has not, and, third, the keeping of accounts in a manner acceptable to a public service commission. Mr. Dow was of the opinion that there was nothing radical in the station, inasmuch as it contained apparatus practically the same as that in the Delray Station.

Reginald Pelham Bolton, of New York, said that the rates are such as to offer little inducement to those consumers whose business is most desirable in producing a high load factor and that this rate does not include any service charge and is drawn merely on the relation of connected capacity and monthly consumption. He wanted to know if there were any data in the paper which justified the expectation that the small consumer can be served at the rate of 3c. per kw.-hr. without loss, which must be borne by other consumers or by a deficit in operation.

Mr. Ballard, in his response, said that he was delighted to learn that Mr. Dow did not consider that there was anything at all radical in the Cleveland station. He admitted it was true that everything in the station is the same as at the Delray plant, and inasmuch as this is so there was no reason why the Delray Station should not sell its current at the same price at which the Cleveland plant was selling it; and he hoped to see them do it. Regarding station rating, Mr. Ballard's understanding was that stations at the present time are generally rated at their maximum capacity for a 24-hr. service indefinitely. Tests show that the turbines in the Cleveland plant are capable of 7500-kw. continuous capacity, three giving 22,500 kw. and the 1500-kw. auxiliary machine bringing the total maximum capacity to 24,000 kw. Upon these figures his statements were based. In regard to capacity, in answer to Mr. Cravath's discussion of the 40 per cent. load factor, Mr. Ballard said: "I find it is not difficult for us to get a 40 per cent. load factor—to get it and to average it. We are running along every day between 60 and 80 per cent. load factor. As we build up the load on our stations we will probably secure a much lower power factor than that. We may go down to 40 per cent., but I hope we will not go below that."

Regarding the cost per kilowatt-hour being different for different customers, Mr. Ballard admitted that the plant was radical in that respect, saying: "Outside the question of competition, if there was only one station in the city and every customer had to take its terms or have none at all, you could not make one figure and a uniform load. You could not sell current to all your small resident customers at as low a rate as you would want to sell it to your power customers. On the other hand, you could not charge your power customers at a higher rate than your resident customers. If you did you could not get the business. That is not necessarily following out the plan of the National Electric Light Association of charging all that the service will bear. If you can sell current to large power companies at 1c. you are selling to the majority of them for less than one-half of what they can make it themselves."

Automatic Reclosing Circuit-Breaker*

BY E. C. RANEY

In the application of protective apparatus to the power circuits of industrial plants there are four conditions which should be fulfilled:

1. The current must be quickly interrupted in case of short-circuit or excessive overload.
2. The circuit should not be closed while the short-circuit still exists.
3. To avoid unnecessary delay the circuit should be closed instantly upon the removal of the short-circuit.
4. For the protection of motors on the circuit, power should not be restored until the controllers or starting-box levers have been moved to the "starting position."

The first of the above conditions may be met by placing either a fuse or a hand-operated circuit-breaker in the circuit to be protected. It will be readily seen, however, that the remaining conditions are difficult to meet by either the hand-operated breaker or the fuse, in cases where the line is of considerable length and the load is not in sight of the attendant.

These difficulties were forcibly brought to the writer's attention while in charge of power plants for mine work and while a motor inspector in steel mills. At that time there was no protective device on the market which met all four conditions, and it was the necessity for such a device which led the writer into the work of its development. The automatic reclosing circuit-breaker, here described, is the result of these efforts up to the present time.

THEORY

In order to make a circuit-breaker which will automatically reset after the overload condition has been removed, it is required that a shunt circuit with a resistance be provided around the main contacts, so that after the main contacts are open there may still be a small amount of current to act as an index to the condition of the line. The reclosing mechanism must be responsive to variation in this index current, which variation must be caused by the increase of resistance of the load or short-circuit. For example, take the case of the circuit-breaker on a 250-volt circuit, set at 500 amp. When the load resistance becomes such that more than 500 amp. will flow, this resistance will be

$$R = \frac{E}{I} = \frac{250}{500} = 0.5 \text{ ohm or less}$$

In case of a short-circuit the resistance of the load becomes practically zero and the breaker must be so constructed that it will not reclose while the load resistance is less than 0.5 ohm. Since in practical circuits it is always permissible to have lights or a constant load connected to circuit, the breaker should be capable of reclosing whenever the load resistance has reached a value slightly above that which caused the breaker to open. Assume that the constant load is 250 amp. and the motor load 250 amp. in the foregoing example. The load resistance will then never be greater than 1 ohm, which will require that the breaker shall not close on a load resistance of less than 0.5 ohm, but will reclose before the resistance has been increased to 1 ohm. In other words, the reclosing mechanism must be sensitive enough to respond to a change of resistance of less than 0.5 ohm in the load circuit.

The resistance of the shunt circuit around the breaker must be 125 ohms, if 2 amp. is allowed to flow at 250 volts on short-circuit as an index current. In commercial circuits the voltage variation is likely to be 10 per cent. or more, which means that the current variation through the 125-ohm shunt may be 10 per cent. of 2, or 0.2 amp. due to that cause alone. The variation of current in the shunt circuit resistance, caused by the load resistance being increased from 0 to 1 ohm, will be

$$2 - \frac{250}{126} = 0.096 \text{ amp.}$$

which is less than the variation due to permissible voltage variation.

It was this consideration which led to the adoption of the shunt circuit used in the present breaker, where two paths are provided for the current after passing through the load. In a branch circuit carrying a definite amount of current,

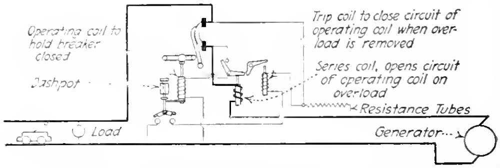


DIAGRAM ILLUSTRATING OPERATION OF CIRCUIT-BREAKER

the latter divides in the two branches inversely proportional to their respective resistances. When the load resistance is practically zero, on account of a short-circuit, nearly all the current flowing through the shunt resistance passes through the load circuit; but when the short-circuit is removed and the load resistance is increased to 1 ohm, if the load resistance coil has 1 ohm, then the current will be equally divided in the two branches and the current variation in the coil will be from 0 to 1 amp., which may be made enough to operate a relay setting the reclosing mechanism into operation.

OPERATION

Referring to the diagram, Fig. 1, it will be seen that the main contact brush is moved to the closed position and is held closed by the operating coil. The main load current passes through a series coil and main contacts. In case of an overload current in the series coil, its armature or core is raised and opens a contact which breaks the circuit of the operating magnet and allows the breaker to open.

The contact arm controlling the current in the operating coil is now held open by a latch until the trip coil operates to release the latch. After the opening of the main contact a small current is permitted to flow around the breaker through a high resistance. This current has two paths leading to the line of opposite polarity, one path around the breaker and through the load, and the other through the trip coil and the dashpot bridge. So long as there is a short-circuit or low resistance on the load circuit, this index current will be shunted past the trip coil, but whenever the short-circuit is removed or the load resistance is increased to a certain amount, enough current will be forced through the trip coil to operate the latch and allow the contact arm to again close the circuit of the operating coil. The breaker is then instantly closed by this action.

A dashpot is provided to prevent the breaker from closing instantly after being opened by a momentary overload. The object of this is to give sufficient time for motors to come to rest and for starting-box levers to be moved to starting position before the breaker recloses, regardless of the cause of the opening.

Briefly stated, the action is as follows: The breaker opens in case of either an overload or short-circuit, and remains

*From a paper read before the Ohio Society of Mechanical, Electrical and Steam Engineers.

open a few seconds in either case. At the expiration of this time limit, it closes, provided the overload condition has been removed; it remains open so long as a short-circuit exists and closes instantly upon its removal.

Recent Court Decisions

Digested by A. L. H. STREET

Electric Power as a "Municipal Purpose"—Provision in an electric power company's franchise granted by a city requiring the company to furnish power to the city for "municipal purposes," on certain terms, extends to the furnishing of current to operate an electric-light plant. (Colorado Supreme Court, City of Colorado Springs vs. Pike's Peak Hydro-Electric Co., 140 "Pacific Reporter," 921.)

Assumption of Risk by Engineer—An engineer in a stationary plant assumes the risk of falling into a pit after another employee has left the trapdoor covering it open, where he knows that it is apt to be open any time, according to the holding of the Massachusetts Supreme Judicial Court in the late case of Burnett vs. Worcester Brewing Corporation, 106 "Northeastern Reporter," 597.

Validity of Condemnation Statute—In a proceeding by an electric power company to condemn land for use of the company, under the laws of Tennessee, which restrict the right of condemnation to corporations, the landowner cannot question the validity of such laws on the ground that they constitute an unjust discrimination against individuals and partnerships who are not accorded the right of condemnation, since he is not injuriously affected by any such discrimination that may exist. (Tennessee Supreme Court, Noell vs. Tennessee Eastern Power Co., 169 "Southwestern Reporter," 1169.)

Right of Power Company to Condemn Land—In a decision announced by the Minnesota Supreme Court, the Minnesota Canal & Power Co. is denied the right to condemn land for one of its projects, on the ground that the enterprise could not be accomplished without impairing the navigability of the waters of the Birch Lake drainage basin. The court holds that a power company, or other public service corporation, cannot divert water from the navigable streams of one drainage basin into those of another basin, if the diversion impairs the navigability of the former; and that private property can be condemned only when the condemnation subserves some lawful public use.

Extent of "Water Power" Rights.—"Horsepower" Judicially Defined—When the right is granted to use the water of a canal or stream for the development of "water power," the grantee acquires no right to use the water for any purpose other than the propulsion of machinery; no water may be diverted or consumed for condensation purposes. This point was recently decided by the Pennsylvania Supreme Court in the case of the Eastern Pennsylvania Power Co. vs. Lehigh Coal & Navigation Co., 92 "Atlantic Reporter," 47. Referring to the term "horsepower," the court finds that it "has in popular acceptation a fixed, definite meaning. As originally employed it expressed the power of a steam engine. It has come to mean the unit in estimating the power required to drive machinery."

What Constitutes a "Stationary Steam Engine?"—Is a steam engine, which has been set upon a concrete foundation and so bolted and braced as to be free from vibration and which is used in quarrying rock and may be so used for two or three years, a stationary engine within the meaning of an ordinance prohibiting operation of stationary steam engines within certain limits in a city without first obtaining a license? This question, which was recently presented to the Massachusetts Supreme Judicial Court in the case of McDonough vs. Almy, 105 "Northeastern Reporter" 1012, was answered by that court in the affirmative. Justice Crosby said, in announcing the decision: "Whatever may have been the character of the engine when it was brought to the plaintiff's land, we have no doubt that when it was set upon the concrete foundation and permanently attached thereto for the purpose of being used two or three years, it became a 'stationary steam engine' within the meaning of the ordinance."

Remedy for Breach of Contract—According to the decision of the West Virginia Supreme Court of Appeals in the case of United Fuel Gas Co. vs. West Virginia Paving & Pressed Brick Co., 82 "Southeastern Reporter," 329, suit will not lie to enjoin a manufacturer from breaking a contract to buy fuel from plaintiff exclusively for a certain period. The court holds that the fuel company's only remedy is a suit to recover damages for breach of the contract. The defendant agreed to purchase from the plaintiff, for a period of three years, all the natural gas it should use in its manufacturing plant, and to pay for the same monthly at certain prices per thousand feet, graduated according to the quantity used. About the middle of the term the defendant purchased natural gas from another gas company and ceased using the plaintiff's product, whereupon the plaintiff applied for an injunction to restrain the defendant from purchasing gas from the other company during the term of the contract.

Effect of Power Rate Ordinance on Existing Contracts—When a consumer of electrical power makes a contract with a public service corporation for service, the parties are conclusively presumed to have contracted in contemplation of the power of the proper public authorities to fix rates, according to a decision handed down the other day by the Supreme Court of California in the case of Pinney & Boyle vs. Los Angeles Gas & Electric Corporation, 141 "Pacific Reporter," 620. The effect of this decision is to nullify the contract rate on a higher or lower rate being established by public authority. Plaintiff used electrical power to operate its machinery, and made a contract with defendant for future service. During the life of the contract, the city of Los Angeles adopted an ordinance fixing a schedule of rates which was higher for the service involved than that fixed by the contract, and the defendant declined to furnish service at the contract rate. The decision of the Supreme Court upholds the defendant's position and overrules the plaintiff's contention that the ordinance is invalid.

Power of Traction Engines—When a contract for the sale of a traction engine contains a warranty on the part of the seller that the engine will develop a certain horsepower, but does not specify whether the power is to be developed at the belt or at the drawbar, the transaction will be governed by a trade custom placing an interpretation on the point, according to a late decision of the Texas Court of Civil Appeals in the case of Southern Gas & Gasoline Engine Co. vs. Adams & Peters, 169 "Southwestern Reporter," 1143. Under the evidence in this case, such a contract is held to be properly interpreted under a trade custom requiring the rated horsepower to be developed at the drawbar. Referring to the rule of law that the provisions of a written contract cannot be varied by showing oral conversations or trade customs which are clearly inconsistent with such provisions, the court said:

> It is not varying the terms of a written instrument to explain what is meant by a term used therein, especially a scientific or trade term which is not generally understood. Here we have the written instrument merely stating that the engine is to develop 20 hp. It is nowhere stated that it is to develop that power at the belt or drawbar, and the only way a layman could understand the term would be by proof as to what is meant by such a term. If it had stated that the power should be tested at the drawbar or belt, there could be no question that oral evidence could not be introduced which would tend to vary the writing. But parol evidence is admissible to aid in the interpretation of a scientific or trade term.

Another Feeder Accident in Cleveland

The municipal lighting plant at Cleveland celebrated the end of the year by a short-circuit in an overhead feeder leading out of the West 41st St. substation, which is the distribution center for the part of the city bounded by Lake Erie, West 65th St., Brooklyn and west of the Cuyahoga River. The trouble started about 8 p.m. on Dec. 31, and service was not restored till after midnight. It is stated that the cause of the trouble was a short-circuit in changing over feeders to consumers who formerly were served from the South Brooklyn plant to the new plant on East 53d St. In the area within which service was cut off, several hospitals reverted to oil lamps or gas, street lights were out and a number of moving-picture shows had to suspend operations.

Long Southern Electric Transmission

The Tennessee Power Co.'s Sequatchie Valley transmission line was completed about the middle of last December. Electric current was then turned on from the $10,000,000 power plant at Hale's Bar (of which the Tennessee Power Co. is now the largest customer) to both of the three-phase conductor circuits.

Although the generators have been connected to the transmission line since last August, only one of the three-phase circuits had been in full working order until mid-December. The transmission line is one of the most permanently constructed in the South and the longest line of the kind, voltage capacity considered, in that part of the United States.

College, the village at which the Brady power plant is connected with the Ocoee-Nashville line, is about 36 miles from Hale's Bar on the Tennesseee River. The voltage capacity of the connecting line is 120,000, or nearly double that of the line from the two Ocoee plants to Chattanooga and Knoxville.

The two circuits, each three-phase, consist of six heavy aluminum cables. One circuit is of 250,000 and the other of 400,000 circ. mils area. At Hale's Bar the Tennessee River is spanned by a 2331-ft. stretch of steel-core aluminum cables of ⅞-in. diameter, suspended between four steel towers 60 ft. high. The towers are set on high elevations so that the cables are 115 ft. above the water. There are 435 galvanized steel towers supporting the double circuit between Hale's Bar and College, the towers being spaced at intervals averaging 453 ft. The tops of the towers are connected with a ⅜-in. ground wire.

The insulators of the high-powered cables are the suspension-type porcelain disks, eight units to each insulator, except at the river crossing, where specially constructed insulators are used to support the heavy span. They are made of treated wood strips inclosed in oil-filled porcelain shells, the largest of the kind ever made; no others like them are in use. The first and eighth disks are 6½ ft. apart, and the mechanism holds the cable 12 ft. from the steel tower's supporting arm.

OBITUARY

JOHN McDONALD

John McDonald, an engineer well known locally and in the N. A. S. E., died of heart failure at his home in Ludlow, Vt., Dec. 17, 1914. He was 63 years of age. The greater part of his life was spent in engineering work.

ENGINEERING AFFAIRS

Award of the John Scott Medal—The city of Philadelphia, acting on the recommendation of The Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Arthur Atwater Kent, of Rosemont, Penn., for his "Unisparker," an essential element of the Atwater Kent ignition system for automobiles, consisting of a contact breaker, governor and distributor, in one structure, and to Elmer Ambrose Sperry, of New York, N. Y., for his gyro-compass.

On battleships under action, the shifting of large masses of magnetic material precludes the use of the magnetic compass, and even on ordinary iron vessels, the material of the ship and its disposition must be compensated for. The gyro-compass is entirely nonmagnetic and is unaffected by the proximity of iron.

The Engineering Foundation—A noteworthy incident in the history of the profession of engineering in the United States will be the inauguration of The Engineering Foundation on Jan. 27, 1915, in the auditorium of the United Engineering Society in New York. The Engineering Foundation is a fund to be administered for the advancement of the arts and sciences connected with engineering and the benefit of mankind, the basis of which is the initial gift of a considerable sum by a noted engineer for this purpose. The American Society of Civil Engineers, the American Institute of Mining Engineers, The American Society of Mechanical Engineers and the American Institute of Electrical Engineers are to be represented equally in the administrative Board of The Engineering Foundation by election by the Board of Trustees of the United Engineering Society, which had been made the custodian of the fund. All members and friends of the engineering profession are invited to these inaugural ceremonies.

TRADE CATALOGS

Massey Machine Co., Watertown, N. Y. Catalog No. 7. Governors, Class M. Illustrated, 16 pp., 6x9 in.

Watson-Stillman Co., Aldene, N. J. Booklet. Kromax leather packings. Illustrated, 16 pp., 3½x6 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-S. Small power driven compressors. Illustrated, 16 pp., 6x9 in.

Neil & Smith Electric Tool Co., Cincinnati, O. Catalog No. 4. Portable electric drills, buffers, grinders, screwdrivers, etc. Illustrated, 56 pp., 6x9 in.

BUSINESS ITEMS

The Cling-Surface Co., of Buffalo, N. Y., has prepared a special calendar for members of the N. A. S. E., copies of which it will gladly mail free on request as long as the supply lasts.

The Lagonda Mfg. Co., Springfield, Ohio, has just published a new 32-page booklet on the Lagonda Boiler Tube Cleaners. It is called catalog L-8—contains many illustrations showing details of construction and also cleaners in actual use, and copies are mailed on request.

The New York office of the Kerr Turbine Co., Wellsville, N. Y., will hereafter be located in Room 801, Singer Bldg. Annex. Mr. Benjamin G. Fernald has been appointed district manager. Mr. Lawrence G. Hanmer will continue to be associated with the New York office and arrangements have been made for prompt and effective attention to all inquiries.

The Files Engineering Co., of Providence, steam specialists and engineers, have established a branch office at 120 Kossuth St., Bridgeport, Conn., where they will contract for power, heating, drying, evaporating and steam specialty work of every description. They request catalogs and other literature descriptive of apparatus and appliances relating to these lines sent to their Bridgeport office.

"Cochrane Multiport Vales," a booklet of 72 pages, just issued by the Harrison Safety Boiler Works, 17th and Clearfield St., Philadelphia, Penn., describes the multiport valves introduced by that concern for back-pressure, relief and vacuum service, flow service in connection with mixed flow turbines, and check-valve service with bleeder or extraction turbines. In addition to full descriptive and tabular matter, the book contains numerous diagrams and layouts, also data on the effects of air in condensers and upon turbine performance.

A booklet worth having is the new booklet issued by the United States Graphite Co., Saginaw, Mich., on the subject "U. S. G. Co.'s Mexican Graphite Paint—Its Uses and Users." It is an excellent booklet from the standpoint of printing as well as subject matter. Fine halftones are used throughout, illustrating many buildings, bridges, etc., where the paint was used. Complete details are given about graphite, the care used in making the paint, and the "reasons why" it should be used. And letters are used to show what success users have had with it. It's a 64-page booklet and is sent on request to anyone interested in graphite paint.

Among recent sales of Bruce-Macbeth gas engines, made by the Bruce-Macbeth Engine Co., Cleveland, Ohio, are the following: Magnolia Pipe Line Co., Fort Worth, Tex., two 150-hp. natural gas engines; Thompson Milling Co., Lockport, N. Y., one 350-hp. natural gas engine; Village of Wellington, Ohio, for municipal lighting plant, one 125-hp. natural gas engine; Kloss Ice Cream Co., Wheeling, W. Va., one 90-hp. natural gas engine; Broadway Market Co., Detroit, Mich., one 90-hp. artificial gas engine; one 70-hp. two-cylinder natural gas engine to J. K. Mosser Co., Parsons, W. Va.; one 150-hp. four-cylinder natural gas engine to Victor Auto Parts Co., Cincinnati, Ohio; one 70-hp. two-cylinder natural gas engine to the Willson Ave. Lumber Co., Cleveland; one 150-hp. four-cylinder natural gas engine to Chisholm Steel Shovel Works, Cleveland, Ohio.

The annual report of the Northern Equipment Co., Erie, Penn., manufacturer of the Copes boiler feed water regulator and the Cope pump goveraor, shows that 1914 was the greatest year in the history of its business. Its sales exceeded its next best year by 9½%. Larger quarters have again become necessary, and in order to provide this it has purchased the plant, equipment and business of the Erie Pump & Engine Works. The new plant is located in the heart of the city and affords excellent shipping facilities. Mr. J. H. Dougherty, formerly with the International Steam Pump Co., has been engaged to take charge of centrifugal pump design, and the well known line of Erie centrifugals is to be improved and extended. A consolidation of the two companies is being perfected and the new combination will be known as the Erie Pump & Equipment Co. The officers of the new company are: E. W. Nick, president and treasurer; D. H. DuMond, vice-president; V. V. Veenschoten, secretary. Mr. John G. Pfadt, former president of the Erie Pump & Engine Works, is not connected with the new company.

CONTRACTS TO BE LET

TREASURY DEPARTMENT, Supervising Architect's Office, Washington, D. C., January 5, 1915.—Plans and specifications are now approaching completion for a central heating, lighting and power plant, to be erected in this city under the direction of this office. These plans and specifications will be ready for delivery on or after January 15. Bids may be submitted for the entire work or for any one of the following sections: Power plant building complete, with steel stacks; boilers; generating apparatus; pumping equipment; condensers; coal and ash handling apparatus; steam and water piping; switching gear; tunnels; substation apparatus, etc. Prospective bidders should immediately submit to this office applications for plans and specifications, stating the portions of the work upon which they desire to bid. If it appears that the applicant is in a position to bid on all of the work in any one of the sections of the project, or upon the entire work, the plans and specifications will be forwarded. No plans or specifications will be furnished sub-bidders or others not in a position to submit a bid on all of the work comprised in at least one section. The Department will be able to allow only about 15 days for the preparation of estimates. At the time plans and specifications are forwarded to bidders the date for the opening of bids will be stated, and this date will not be extended. O. WENDEROTH, Supervising Architect.

POWER

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"GUESS I'LL STICK AROUND A WHILE."

Power Plant of the J. B. Stetson Company

By Warren O. Rogers

SYNOPSIS—A plant in which more capacity was required. The problem was solved by putting in a mixed-pressure turbine, utilizing the exhaust steam from the engines and numerous pumps. The condensing water goes to a cooling tower which, owing to the restricted ground area, is supported on concrete posts in the yard.

When an engineer puts on his "Stetson," he gives but little thought to the power plant which made the manufacture of this hat possible or to the immense factory in which it was made. While the power plant of the J. B. Stetson Co., Philadelphia, Penn., is not new, it has interesting features, and illustrates how more power and greater economy may be obtained in a plant where the engine room cannot well accommodate additional units.

Fig. 1 is a general view of the engine room, which houses three 24x48-in. and two 30x48-in. horizontal engines, one $8\frac{1}{2}$x8-in. single-acting, vertical reciprocating engine, and a Rateau-Smoot mixed-pressure steam turbine which uses the exhaust steam from such engines as are run. Before the turbine was put in, both of the large units and two of the small ones were used, leaving one 250-kw. unit as a reserve. On the average these engines consumed $24\frac{1}{2}$ lb. of steam per horsepower-hour. With the turbine, but one 500-kw. unit and one 250-kw. set are operated, with a large and two small units held as reserve. This means cutting out a 375-hp. and a 750-hp. unit, which at $24\frac{1}{2}$ lb. of steam per hour represents a saving of 27,562 lb. of live steam per hour. Crediting the boilers with evaporating 9 lb. of water per pound of coal fired, a saving of 3062 lb. of coal would be had. This makes $1\frac{1}{2}$ tons per hour, or 15 tons per day of 10 hours, and is a saving of $48.75 per day if the coal cost is $3.25 per ton.

As there are 14 boilers in the three boiler rooms, all connected to the same steam main, and as the turbine is a recent addition to the plant equipment, figures regarding the actual saving in fuel are not available. The foregoing, however, gives a fairly good idea of what the turbine is doing in the way of economy.

Exhaust-Steam Lines

The exhaust line from the two 30x48- and the two 24x48-in. engines begins with a 12-in. pipe and increases to 14-, 16-, 18- and 20-in., as indicated by Fig. 2. The other 30x48-in. engine exhausts into a 16-in. line, which also receives the exhaust from the steam pumps, and a 16x42-in. Corliss engine used to belt-drive a lineshaft in the pump room. This pipe line loops one end of the engine-room basement and joins the 20-in. main exhaust header. Exhaust steam is not only utilized by the turbine, but some is also used in the two 3000-hp. vertical heaters, which are piped as shown. Both are connected to a 30-in. atmospheric exhaust. The exhaust and the main steam lines in the basement (Fig. 3) are supported by brick

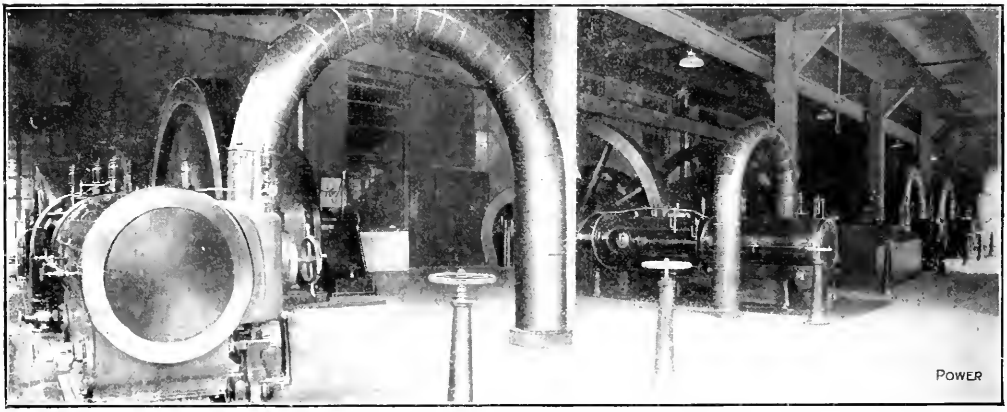


Fig. 1. General View of the Engine Room

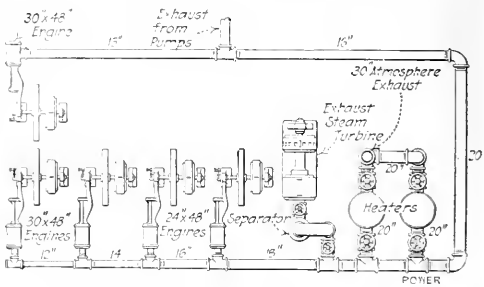


Fig. 2. Diagram of Exhaust-Steam Piping

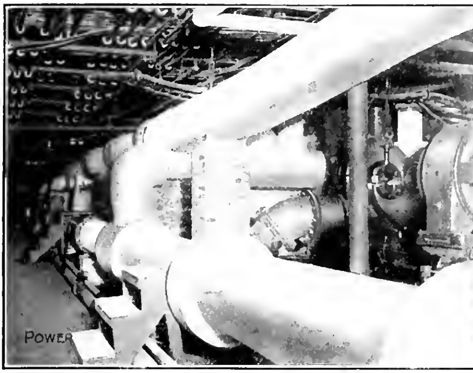


FIG. 3. LIVE- AND EXHAUST-STEAM MAINS

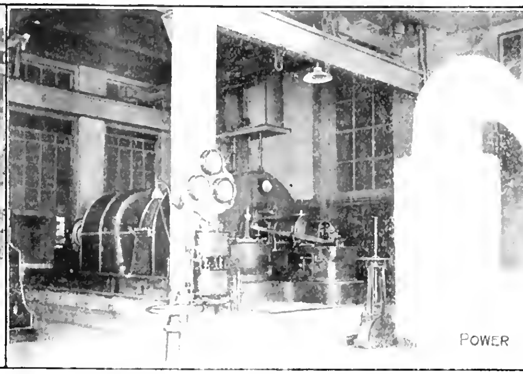


FIG. 4. LOW-PRESSURE STEAM TURBINE

piers; the lower pipe is the exhaust line. The motor-driven circulating pump supplies the surface condenser, which is further to the right, but not shown.

TURBINE AND CONDENSING APPARATUS

The low-pressure turbine (Fig. 4) is of 750-kw. capacity, generating 230-volt direct current at 1500 r.p.m. It is at the end of the engine room and rests on a con-

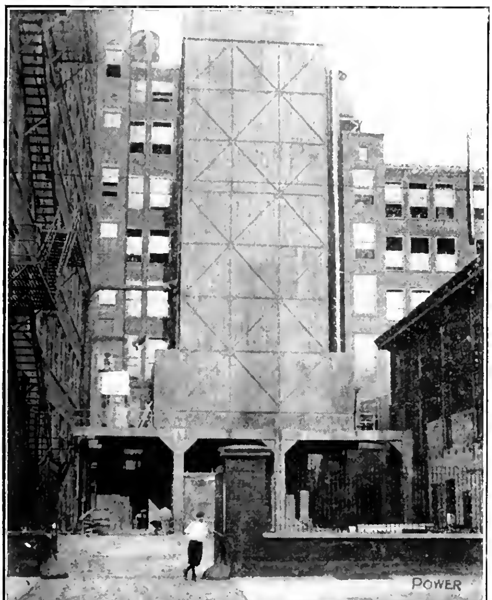


FIG. 5. COMBINED NATURAL- AND FORCED-DRAFT COOLING TOWER

crete foundation. In the basement below the turbine is the condensing apparatus. The surface condenser has 4200 sq.ft. of cooling surface made up of 1-in. outside diameter No. 18-gage tubes. Condensing water is supplied by a 12-in. centrifugal pump, having a capacity of 3000 gal. per min., and being driven by a 70-hp., 220-volt, direct-current motor at 950 r.p.m. The "rotrex" air pump is driven by a 14-hp., 220-volt, direct-current motor.

Owing to a restricted ground area, the cooling tower is in the yard and rests on a concrete base supported by concrete posts (Fig. 5). The tower is 27x27 ft. and is 75 ft. high. The condensing water is cooled by a combination of forced and natural draft, the forced draft being supplied by four 8-ft. fans driven by direct-connected motors. The hot water from the condenser is used in the factory for manufacturing purposes, thus utilizing the heat imparted to it in condensing the steam, the temperature of the water being 90 deg. The water from the cooling tower goes to the condenser at 89 deg. during the ordinary summer temperatures.

There are more than 500 motors throughout the factory

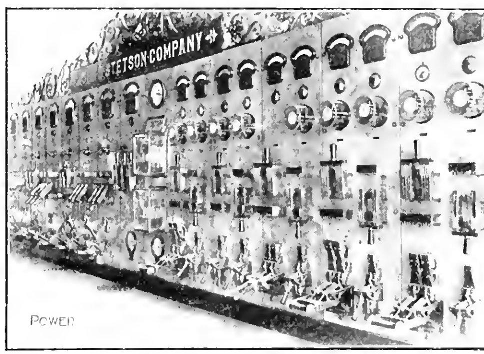


FIG. 6. DIRECT-CURRENT SWITCHBOARD

which range from 1/6 to 70 hp. in capacity. The load on the turbine is from 270 to 3000 amp., and that on the engines is from 3000 to 3500 amp. There is an average load of 6000 amp., or about 1500 kw.

The motor and lighting circuits are controlled from a 14-panel marble switchboard (Fig. 6), the generator panels showing in the foreground. The turbine generator is controlled from a bench switchboard (Fig. 4), between the second and third engines.

BOILERS AND PUMPS

Steam is supplied for the engines and for manufacturing purposes by fourteen water-tube boilers in three rooms. Fig. 7 shows the five large boilers.

Coal is delivered by wagons from the street into two

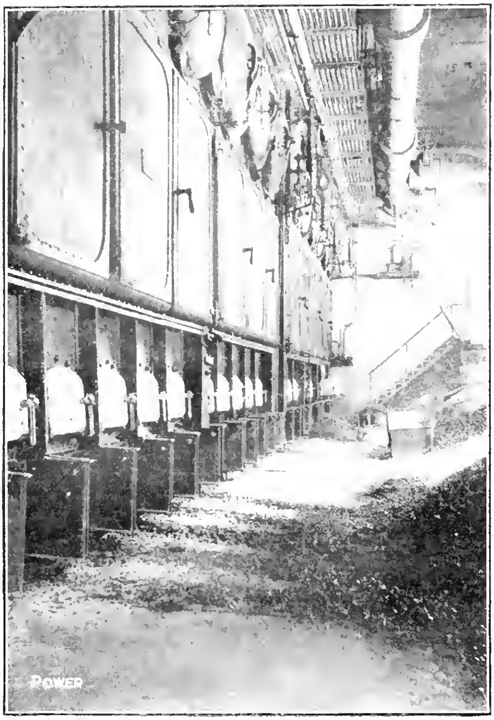


Fig. 7. One of the Boiler Rooms, Containing Five of the 14 Boilers

of the boiler rooms, which are below the street level, but in the third room it is elevated by a bucket conveyor to a storage bin. Ashes are wheeled to an ash conveyor and elevated to a bin on the outside of the boiler house, from which they are loaded into wagons on the street level and carted away.

The pump room (Fig. 8) is a fair-sized steam plant in itself. The largest unit is the 16x12-in. engine, already mentioned. From the lineshaft which this engine drives there are belted a 5½x8- and an 8x10-in. triple-plunger house pump for supplying fresh water to the factory, washrooms, etc. Both are equipped with regulators which maintain a pressure of 90 lb. on the pipe system.

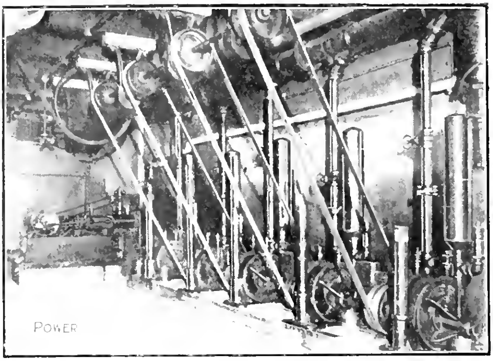


Fig. 9. Belt-Driven High-Pressure Blowers

Air for the factory is supplied by two compressors, one belt-driven from the lineshaft, the other being a compound steam-driven unit. Both supply air at 90 lb. pressure.

The factory has a system of vacuum cleaning. Vacuum is produced by two vacuum pumps, driven by a noiseless chain drive; each has a 24x18-in. cylinder and rated at 60 hp.

The refrigerating system not only keeps a proper temperature in the storage room for hat bodies, but it cools the drinking water for the factory. Since the introduction of this system of cooling the drinking water the rate of sickness among the workmen has greatly decreased. The system for cooling the brine supply consists of one 45-ton, 14x32-in. ammonia compressor, two 5x4-in. brine pumps, and the necessary apparatus. The drinking water is pumped to the factory by two 10x6x10-in. duplex steam pumps.

Boiler-feed water is supplied by a 14 & 20x40x18-in. and a 12x8½x12-in. duplex pump, working against 120 lb. pressure. Among the other apparatus is a 12x7x10-in. cold-water house pump, two vacuum pumps for the factory heating system, and a hydraulic pump for producing water pressures up to 300 lb. per sq.in. for the factory on various presses used in the process of manufacture.

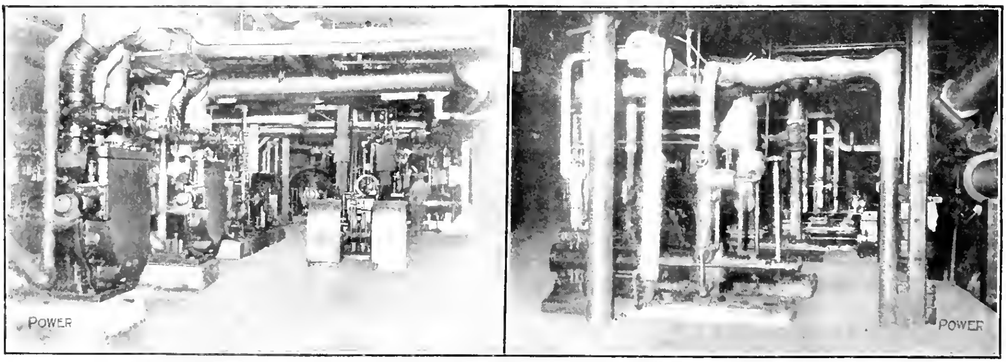


Fig. 8. Two Views of the Pump Room, Which Is a Fair-Sized Power Plant in Itself

At one end of the pump room is a set of five belt-driven, high-pressure blowers (Fig. 9) for the gas-heated irons in the factory. Each is fitted with a tight and loose pulley and is driven from an overhead shaft.

Miscellaneous

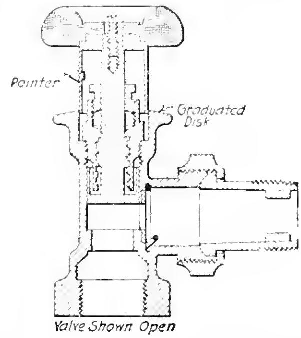
For the convenience of the employees a garage has been built, having steam heat, electric light, hot and cold water, compressed air, water for washing cars, asbestos and iron lockers, and a small machine shop for light repair work; also a charging station for electric automobiles. Out in the yard there is a rack for the accommodation of bicycles; they are stacked on end to occupy a minimum of room. A hospital is also maintained by the company and a large auditorium is available for entertainments.

The factory is wired with six trunk telephone lines, serving over 200 instruments, placed at convenient points. The 22 elevators are equipped with telephones, making it an easy matter for heads of departments to be reached when away from their desks.

A system of call bells has also been put in, so that no matter where the head of any department may be, the ringing of his signal denotes that his presence is required at his office.

amount of steam condensed per square foot of radiation under average demand conditions.

When used in connection with the atmospheric system



Section through Atmospheric Radiator Valve

of steam heating, it affords control of individual radiators, and just the amount of steam needed is used in each radiator to maintain the desired temperature.

PRINCIPAL EQUIPMENT OF THE JOHN B. STETSON CO. POWER PLANT

No. Equipment	Kind	Size	Use	Operating Conditions	Maker
3 Engines	Reciprocating	24x48-in.	Main units	90 r.p.m. saturated steam	Brown Engine Co.
2 Engines	Reciprocating	30x48-in.	Main units	90 r.p.m. saturated steam	Brown Engine Co.
1 Engine	Reciprocating	8x8½-in	Used after work hours	Saturated steam	Westinghouse Machine Co.
1 Turbine	Rateau-Smoot	750 kw	Main unit	1500 r.p.m. exhaust steam	Ridgeway Dynamo & Engine Co.
3 Generators	Direct current	250 kw	Main generators	90 r.p.m., 230 volts, 800 amp.	Crocker-Wheeler Co.
2 Generators	Direct current	500 kw	Main generators	90 r.p.m., 230 volts, 2000 amp.	Crocker-Wheeler Co.
1 Generator	Direct current		Used after hours	250 volts	Westinghouse Elec. & Mfg. Co.
1 Generator	Direct current	750 kw.	Main generator	1500 r.p.m., 230 volts, 3000 amp.	Ridgway Dynamo & Engine Co.
1 Engine	Corliss	16x42-in.	Driving lineshaft, pump room	101 r.p.m.	Allis-Chalmers Co.
1 Condenser	Surface	4200 sq.ft. cooling surface	With turbine	27½-in. vacuum	C. H. Wheeler Mfg. Co.
1 Motor	Direct current	70 hp.	Driving circulating pump	950 r.p.m., 220 volts	General Electric Co.
1 Pump	Centrifugal	12-in.	With condenser	950 r.p.m.	C. H. Wheeler Mfg. Co.
1 Pump	Air Rotrex	18x36-in.	With condenser	225 r.p.m.	C. H. Wheeler Mfg. Co.
1 Motor	Direct current	14 hp.	Driving air pump	225 r.p.m., 220 volts	Sprague Electric Works
2 Heaters	Berryman	3000 hp.	Feed water	Exhaust steam	Benj. F. Kelley & Sons
6 Boilers	Parker down draft	500 hp.	Steam generation	Hand fired	Parker Boiler Co.
3 Boilers	Parker down draft	630 hp.	Steam generation	Hand fired	Parker Boiler Co.
5 Boilers	Parker down draft	750 hp.	Steam generation	Hand fired	Parker Boiler Co.
1 Pump	Triple plunger	5¼x8-in.	House service	Belt driven	Platt Iron Works
1 Pump	Triple plunger	8x10-in.	House service	Belt driven	Platt Iron Works
1 Compressor	Simple		Factory use	90-lb. pressure	Ingersoll-Sargent Drill Co.
1 Compressor	Compound		Factory use	90-lb. pressure	Ingersoll-Sargent Drill Co.
2 Pumps	Vacuum	24x18-in.	Vacuum cleaning system	Chain belt driven	Vacuum Cleaning Co.
1 Compressor	Ammonia	14x32-in., 45-ton cap.	Refrigeration	Steam driven	De La Vergne Mch. Co.
2 Pumps	Power plunger	5x4-in.	Pumping brine	Belt driven	Fairbanks, Morse Co.
2 Pumps	Duplex	10x6x10-in.	Cold drinking water	Steam driven	Henry R. Worthington Co.
1 Pump	Duplex, comp.	14&20x10x18-in.	Boiler feed	Against 120-lb. pressure	C. H. Wheeler Mfg. Co.
1 Pump	Duplex	12x8½x12-in.	Boiler feed	Against 120-lb. pressure	Advance Pump & Compressor Co.
1 Pump	Duplex	12x7x10-in.	Cold water for factory		Henry R. Worthington
1 Pump	Vacuum	8x12x12-in.	Heating system	During cold weather	Union Steam Pump Works
1 Pump	Vacuum	8x12x16-in.	Heating system	During cold weather	Union Steam Pump Works
1 Pump	Hydraulic	12x9¾x12-in.	Factory hydraulic system	Steam driven	C. H. Wheeler Mfg. Co.
1 Pump	Hydraulic		Factory hydraulic system	Steam driven	Union Steam Pump Works
5 Blowers	High pressure	4 No. 3—1 No. 4	For gas	Gas heated irons	American Car Furnace Co.
1 Tower	Forced and natural draft	27x27x75-ft.	Cooling condensing water	Forced and natural draft	C. H. Wheeler Mfg. Co.
4 Fans	Forced draft	8 ft.	Cooling tower	Motor driven	C. H. Wheeler Mfg. Co.
4 Motors	Direct current		Driving tower fans	220 volts	General Electric Co.

In connection with the engineering staff, Chief Engineer D. J. Wattis also has supervision of the machine shop, the force totaling 140 men.

Adsco Graduated Radiator Valve

The improved Adsco radiator valve, illustrated herewith, is calibrated to supply a definite amount of radiation, and is designed to supply steam to standard sizes of radiators of the hot-water type.

The various capacities of valves are arranged in multiples of five square feet of direct radiation. These capacities have been established as the result of tests to determine the ratio of the amount of steam under a given pressure passing through the radiator valve, to the

The valve body is fitted with a graduated disk at the outlet. The valve travels from a closed to a full open position with a three-quarter turn. A pointer on the valve stem indicates on the graduated disk any fractional position between the two extremes. The claims for this valve, manufactured by the American District Steam Co., North Tonawanda, N. Y., are economy, freedom from clogging and that it will not stick after remaining idle.

A Common Error when trouble appears in the form of scored cylinders and valves is to hold the oil responsible for the damage. After the necessary repairs are made and possibly the mechanical cause of the trouble removed, another oil is substituted with very satisfactory results. Both oils may have come from the same field, had the same composition and physical properties, in fact, be the same oil, but from barrels with different trade names, so that the admiration for the second, together with the condemnation of the first, would be unjustified.

Lauson Heavy-Duty Kerosene Engine

Recently the John Lauson Manufacturing Co., New Holstein, Wis., placed on the market a four-cylinder, vertical, heavy-duty oil engine, of 80 and 100 hp., with cylinders $10\frac{1}{4}$x12 in. and 11x12 in., respectively. Primarily, the engine is intended for small lighting-plant work, the regulation being close enough to permit operating alternating-current generators in parallel.

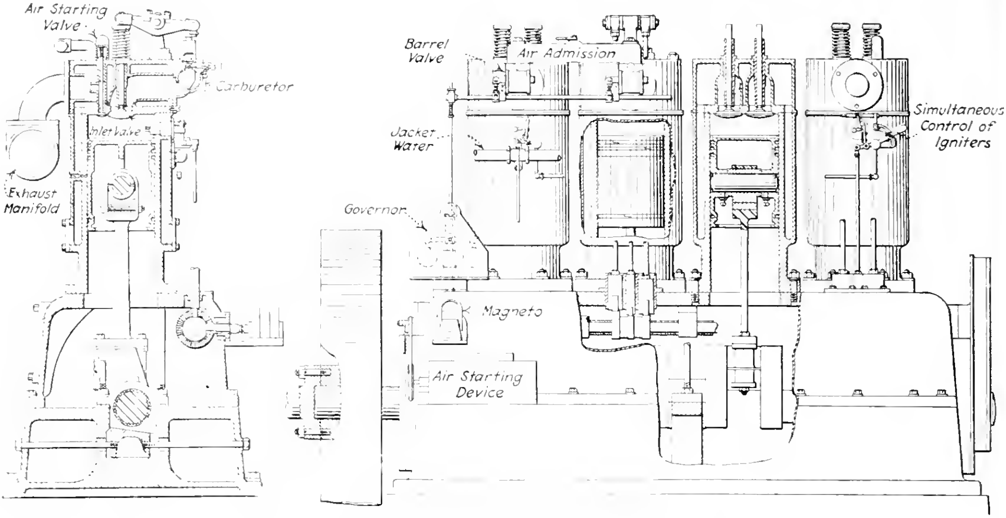


FIG. 1. TRANSVERSE SECTION AND LONGITUDINAL VIEW OF LAUSON ENGINE

The general construction is shown in Fig. 1. The crank case is of the two-piece type split horizontally at the center of the shaft. The valves are mechanically operated and located in the head. Make-and-break ignition is employed and cooling water for the cylinder jackets is supplied by a pump driven through a chain and sprocket by the main shaft.

The feature of the engine is the special carburetor or "Venturia" mixing nozzle, of which there is one for each cylinder. The principle of this device is to maintain a high velocity of air through a venturi tube having radial holes in its restricted portion through which the fuel is drawn by the suction of the air. The amount of air passing through the nozzle is controlled by the governor. The carburetor consists of a cast-iron body containing a cylindrical throttling chamber within which is fitted the barrel valve shown at *F*, Fig. 2. This valve is controlled by the governor through a bell crank and a horizontal shaft running the length of the four cylinders.

Fuel is admitted through the nozzle *D*, which has two sets of holes. The upper set is for the admission of gasoline for starting and kerosene for running, and the lower set for the admission of water to prevent premature ignition at full load. Three needle valves, one for each liquid, control the supply to the nozzle. On each side of the nozzle *D* is a port *I*, and when the engine is at rest these ports are wide open. Below the nozzle the governing port *P* will also be open. Thus, a certain proportion of the air passes through ports *I* and the balance through the nozzle *D*. As soon as the engine picks up in speed, valve *F* is rotated by the governor, gradually closing the ports *P* and *I*, so that a greater proportion of the air is deflected through the nozzle, thus maintaining a practically uniform velocity at this point. The high velocity of the air and the feeding of the fuel through a number of small holes insure atomization and a proper mixture before the fuel passes to the cylinder. A butterfly valve controlled by the handle *E* is provided to facilitate starting and for additional air adjustment at full load.

The igniters are of standard make-and-break design and operated from the camshaft. Two timing adjustments are provided, one individual and one simultaneous, the latter being used to shift all igniters at times of starting by a single lever. The mechanism is shown in Fig. 1. An insulated brass bar charged by a gear-driven alternating-current magneto is placed above the igniter plug. A spring coming in contact with the bar puts the igniter in the circuit and eliminates the need for wiring.

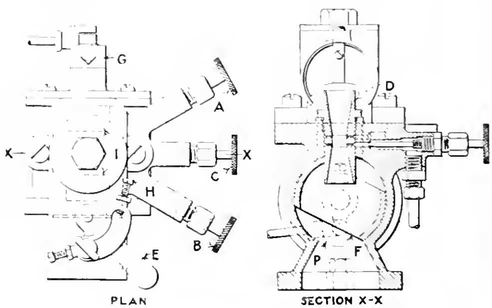


FIG. 2. THROTTLING CHAMBER

For starting, a special device furnishes the air in turn to each cylinder. The device consists of a main body having four radial air ports connected by piping to the different cylinders. These ports are covered and uncovered by a rotary disk valve having one port. The valve is held to its seat by the pressure of the air and is free to revolve when the air is shut off. Rotation is effected by means of a flexible coupling between the device and the camshaft. Compressed air, provided in the usual way, is admitted to the cylinder through a small valve in the head, which is shown at the left in the sectional view of the engine. As soon as the engine fires, this valve is held to its seat by the pressure within the cylinder. The engine is run for about ten minutes on gasoline and the fuel is then changed to kerosene.

The fuel reservoir has three compartments: one for gasoline, one for kerosene and one for water. The gasoline and kerosene compartments are kept full by means of pumps, and the water is controlled by a float inside the chamber.

The governor is of the vertical flyball type driven from a bevel gear on the camshaft. It is inclosed, as indicated in Fig. 1, and the speed may be adjusted by shortening or lengthening the rod from the governor to the regulating valve under its control. Lubrication of the five main bearings and the cylinders is effected by a force-feed pump. The connecting-rods depend on splash lubrication.

Quarter-Turn Rod Coupling

To obviate the noise and wear of a bevel gear between a jackshaft belt driven by a motor set on the engine-room floor and a centrifugal pump some distance below, C. P. Hall, chief engineer of the Rookery Building, Chicago,

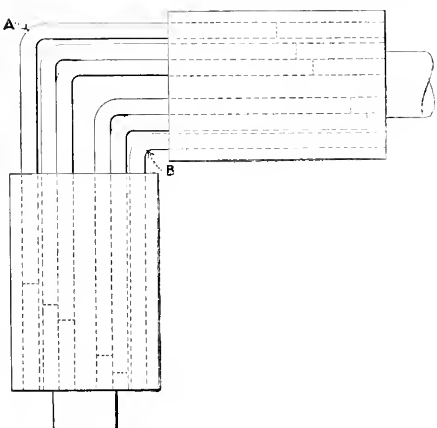


Fig. 1. Diagram of Coupling

invented an ingenious quarter-turn coupling consisting of two heads, bored to receive six rods of equal length. The jackshaft is horizontal and the pump shaft vertical, as indicated in Fig. 2. The coupling heads are merely solid pieces, bored for and keyed to their respective shafts. Within one-half inch of the circumference and spaced evenly around it, six holes are drilled to comfortably receive the rods. These rods are twice the length of a head plus the shortest exposed length shown in Fig. 1. They are free to turn in their sockets and slide lengthwise as the relative movements of the heads demand. When in the extreme position *A*, the ends of a rod are midway in the heads and in position *B* the ends are flush with the outer faces.

At first glance it would look as though the rods would twist together in a single turn of the heads. That this is not the case has been successfully demonstrated by Mr. Hall. Several couplings of the same kind as illustrated are in use in his plant. Fig. 2 shows a coupling connecting a jackshaft, driven by a 3-hp. motor, to a 3-in. centrifugal pump. The speed is 500 r.p.m., and at a distance of only a foot it was impossible to detect any noise from the coupling. The rods are well greased and as a precautionary measure a hood is placed over the coupling. The largest coupling is for a 10-hp. motor, but there is no reason why higher powers could not be transmitted; it is merely a question of size. To be safe the combined area of three rods should be equal to the area of the shaft.

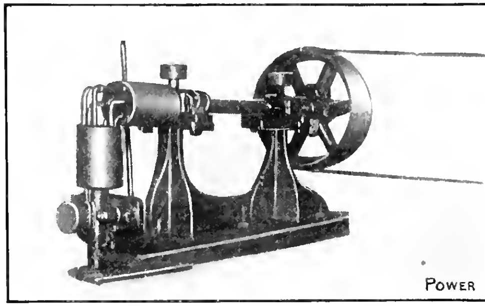
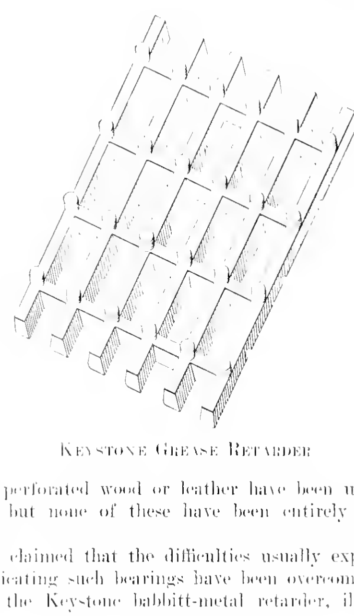


Fig. 2. Jackshaft and Coupling with Hood Removed

Keystone Grease Retarder

On large bearings where grease is used for lubrication, if the grooves are not cut in line with the center of the bearing, part of the journal is without lubrication. Retarders made from copper-wire gauze, perforated copper



Keystone Grease Retarder

plates, perforated wood or leather have been used with grease, but none of these have been entirely satisfactory.

It is claimed that the difficulties usually experienced in lubricating such bearings have been overcome by the use of the Keystone babbitt-metal retarder, illustrated herewith. This retarder is bent to conform to the curve of the journal and is made slightly narrower and shorter than the grease well; the grease is placed on top of the retarder in the usual manner.

The under side of the retarder is grooved, and one edge of each bar is rounded, so that the grease is wedged between the retarder and the journal instead of being scraped off. The grease is spread over the bearing surface and fed into the groove in the bearing cap, providing efficient and economical lubrication.

This device was designed by Thomas O. Organ, consulting engineer of the Keystone Lubricating Co.

Two New Nordberg Engines

SYNOPSIS—Cylinder a plain casting. Balanced poppet valves contained in heads. Valves positively operated by eccentric on lay-shaft and cam. Relief valves avoid over-compression.

Two new types of engine being built by the Nordberg Manufacturing Co., of Milwaukee, Wis., are shown in the shop photographs, Figs. 1 and 2. The former is an 18x32-in. poppet uniflow engine for the city of Bartow, Fla. It will drive directly a 150-kw. alternator at 164 r.p.m. Fig. 2 shows an 18x24-in. poppet valve "counterflow" engine which will be directly connected to a 175-kw. alternator and run at a speed of 164 r.p.m. Waupun, Wis., is to have this unit. All but the lower half of the flywheel on each engine is assembled. The simplicity of design will be apparent, especially that of the uniflow engine.

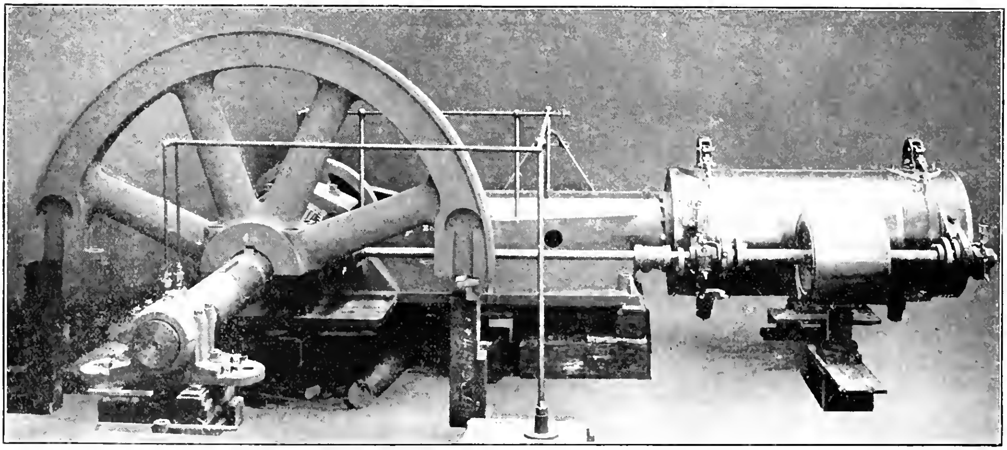


FIG. 1. NORDBERG POPPET-VALVE UNIFLOW ENGINE, 18X32-IN. CYLINDER

The word "counterflow" is used to make clearer the distinction between the uniflow type and an engine into which the steam flows in the ordinary way. So many new engines have been perfected within recent years that there is some confusion as to what the different names mean. The word "uniflow" has been coined to designate an engine in which the steam flow within the cylinder is only in one direction—unidirectional flow. In the usual engine there is a reversal of steam flow; on the out-stroke the flow is toward the advancing piston, and on the return stroke the same steam flows toward the cylinder head. In the uniflow engine the steam is admitted at the ends, as in the ordinary engine, but is exhausted through ports at the center of the cylinder, the piston acting as its own exhaust valve, as shown in Fig. 3.

The uniflow principle has to do with only the cylinder and exhaust-valve design, so that an engine of this type may be fitted with any style of valves and valve-gear for controlling the steam inlet. Corliss valves may be

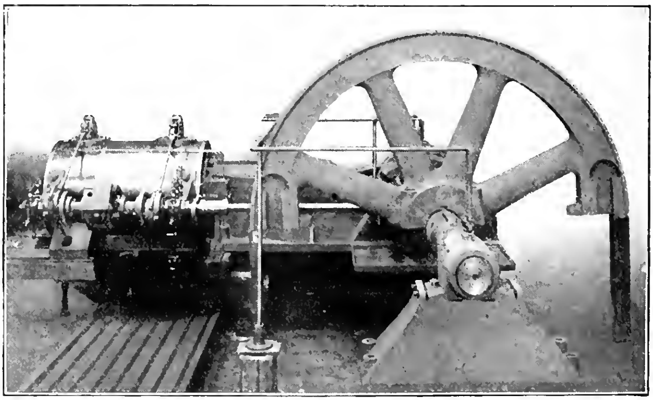


FIG. 2. POPPET-VALVE COUNTERFLOW ENGINE, 18X24-IN. CYLINDER

used, and a number of Nordberg uniflow engines have been so equipped. A description of this engine appeared in the June 11, 1912, issue of POWER. For high pressures and superheats, however, poppet valves are to be preferred.

Line drawings of both of the new engines are shown in Figs. 4 and 5. The frame is the standard Nordberg

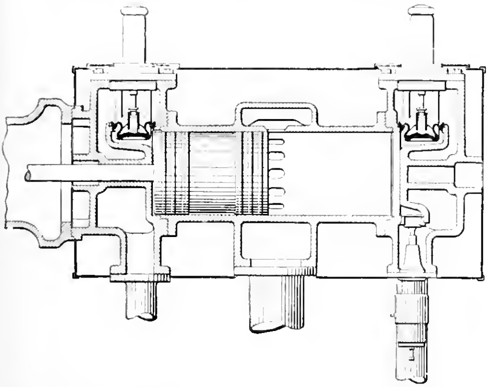


FIG. 3. SECTIONAL VIEW OF UNIFLOW CYLINDER

heavy-duty design with an oil pan cast integral under the crank and rod. The bearing, rods, guides and crosshead are also standard. The cylinders of these engines are of plain cylindrical form without steam chests—this to avoid distortion under high superheat. The steam removed by backing off on the rack. The cylinder may then be removed from the crank-end head. The valves are of the double-beat balanced poppet design, shown together with the operating cam and follower in Fig. 7. The valves seat on removable cages, which are steam tight in the cylinder-head casting. This construction was adopted to obviate the distortion common to seats cast integral with the cylinder casting. These cages can be renewed or removed for regrinding. No stuffing-boxes or metallic packing are used on the valve stems. These are ground to a close fit and then made tight by grooves which prevent leakage, on the principle of the labyrinth used in centrifugal pumps, compressors, etc.

The stubby, compact appearance of the valve bonnets is due to the absence of springs for closing the valves. In this construction the valve is opened and closed positively by one cam oscillated by an eccentric on the lay shaft, the throw of which is varied by an inertia and centrifugal governor located between the eccentrics. The design of cam, eccentric and governor is shown by the illustrations.

In the counterflow type of engine there are four cams—two at each end—one for the steam inlet, the other for the steam exhaust valve. In the poppet uniflow engine there are only two cams—one for each steam-inlet valve—the exhaust, as already explained, being controlled by the piston itself.

The uniflow engine is primarily a condensing engine. Expansion may be carried from high boiler pressure to 26 in. of vacuum within one cylinder at as good economy as ordinarily obtained with a compound condensing engine, owing to the reduction in cylinder condensation

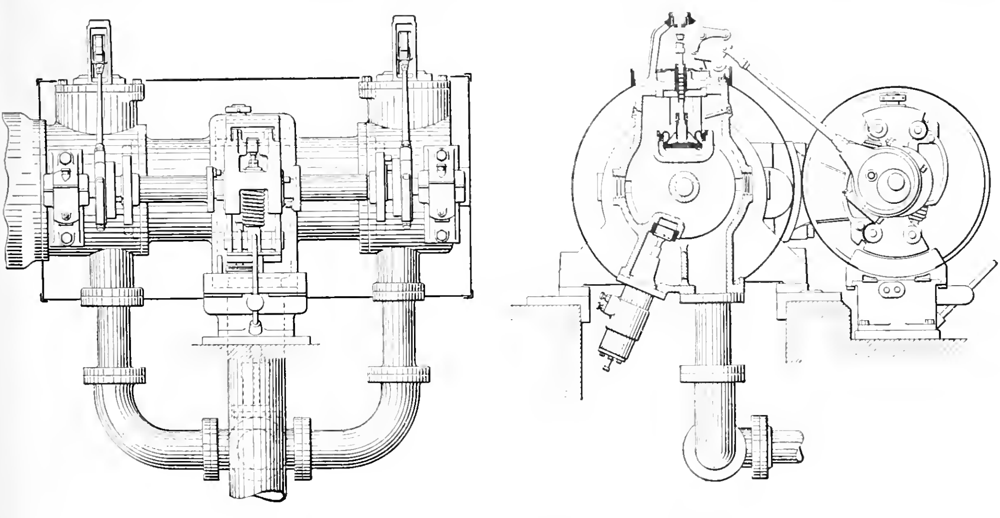


FIG. 4. LONGITUDINAL VIEW AND TRANSVERSE SECTION OF UNIFLOW CYLINDER

is led to each valve separately from the throttle valve placed under the floor. The cylinder heads are cast separately and contain the valves, and, as shown in Fig. 3, the design is such that the entering steam jackets the ends of the cylinder.

The arrangement of the cylinder and heads is shown in Fig. 6. To dismantle, the head with the valves is

effected by the uniflow construction. This type of engine has the further advantage of large overload capacity and a flat steam curve. It is claimed that it will carry 100 per cent. overload with a 10 per cent. increase in steam per horsepower-hour over the full load rate. At half load the steam rate is about 5 per cent. in excess of normal.

An objectionable feature of the uniflow engine is the high compression obtained when the vacuum is lost on when the engine is run noncondensing. In the present design this difficulty has been met by placing an automatic relief valve at each end of the cylinder. One of these valves is shown in Fig. 4. It opens from the clearance

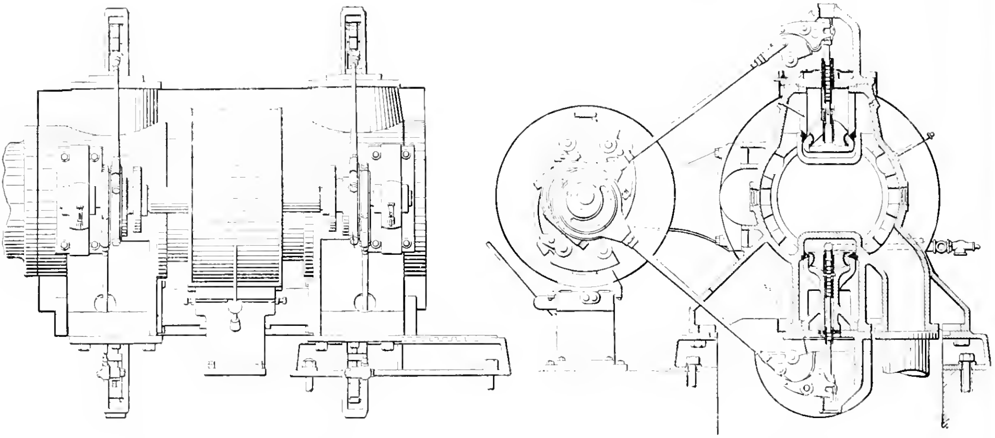


Fig. 5. The Poppet-Valve Cylinder with Positive High-Speed Valve-Gear

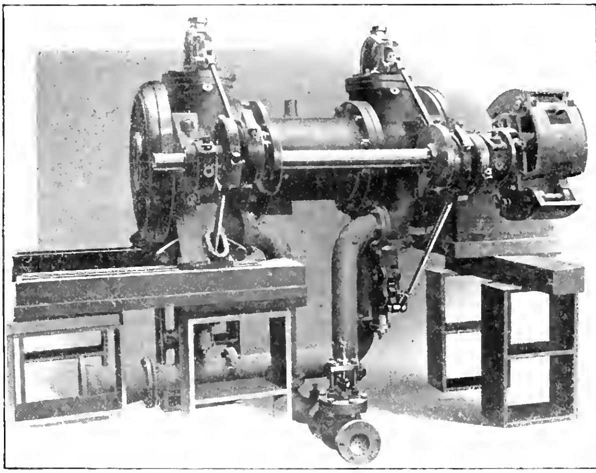


Fig. 6. Cylinder and Heads, before Covered by Lagging, and Valve-Gear

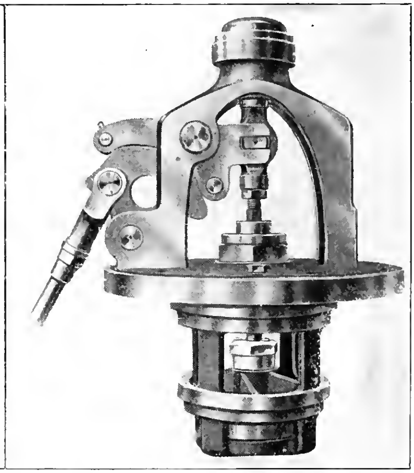


Fig. 7. Balanced Poppet Valve with Operating Cam and Follower

space and discharges the steam in its superheated state at the end of compression back to the steam piping; overcompression is thus avoided.

Pumping Water with Compressed Air—A 12x14¼x14-in. compressor furnished air for a mine pump 14x8x3 in. No other uses were made of the air and the air line was tight. Indicator cards were taken from both the air and steam cylinders of the compressor. The valve adjustments were good and the pistons tight. The total pumping head of the pump, including suction and pipe friction, was 103.1 ft. The water pumped was measured by a 4-in. orifice in a tank at the surface. The over-all efficiency from steam indicated horsepower to useful work done on the water was only 6.81%.

Crankpin Troubles

By C. W. Haynes

One of the common troubles encountered in the engine room is the undue heating of crankpins. Not properly relieving the brasses at the parting is one cause, and another is in not allowing sufficient clearance at the fillets.

A brass with no clearance may run for some time with little or no trouble, but after heating has taken place, it will be found upon taking it down that it has developed a decided tendency to grip the pin. To avoid this the clearance should be ample to reduce the bearing on the brass to the crown of the pin.

In roundhouse work, in a locality where the road was hilly, it was the common practice to reduce the area to nearly one-half of the arc of the brass without bad results. It would seem that this excessive clearance would result in heating, but it did not, even when the engines were pulling hard and running at high speed, or going down hill with the steam shut off, at which times the thrashing of the rods tries the pins severely. This shows that seemingly excessive clearance will not cause heating.

The locomotive engineer has troubles that the stationary engineer does not experience. In dry times the wind blows the dust, and in wet weather the mud between the ties is thrown up into the bearings; then when the oil is used up, out goes the babbitt. If the babbitt is all thrown out, there can be but little injury, but if the engine is stopped and the partly melted babbitt is allowed to freeze on the pin, cutting is liable to occur.

It is essential that the brasses be properly fitted and no high spots left to cause severe local heating. All of the flaky substance which covers a brass after heating should be filed or scraped away. It is not necessary, however, to scrape away all the file marks, which, being crosswise, afford lodgment for oil and are beneficial in newly fitted bearings.

A soft babbitt gives satisfaction when used in the inserts, but it should be peened in or it will get loose. Good results have been secured by fitting the brasses first and babbitting afterward. In doing so it is easy to leave the babbitt a little higher than the crown of the brass, insuring the benefit of the good qualities of the babbitt.

The following experience illustrates the benefits of babbitt inserts in bronze bearings. Certain gasoline engines using phosphor bronze on the crankpins gave trouble frequently until we put two rows of button inserts across each brass. Later, the use of phosphor bronze was discontinued in favor of a high-grade antifriction metal.

Not all the trouble with crankpins, however, is due to mechanical faults. The quality of the oil is responsible in many cases of heating. The superintendent one day wanted to know the cause of the poor condition of the crankpin bearings of a two-cylinder engine. He said the engine must have run dry earlier in the day. It was contended, however, that if the engine had run dry, the metal would have melted, but with a poor grade of oil the bearing had heated gradually, softening the metal and allowing it to crush out at the sides. That same grade of oil did give much trouble later.

When a newly fitted brass is put in hard service, a little tallow in the clearances helps to prevent heating. Fast-running engines must be kept snugly keyed up or the brasses and straps will chafe. When straps are off it is advisable to look them over for cracks, especially in the corners, where they are often easy to see. It is, however, good practice to wipe them carefully and paint with a thin coat of white-lead paint, then strike the strap or rod end with a soft hammer and if there are any cracks the oil in them will discolor the paint, thus indicating the extent of the fracture.

Brasses running loose at high speed will pound themselves hot and may fracture the running parts.

Forced-Draft Cooling Towers

By E. Raymond Goodrich

SYNOPSIS—Analyses and test data of forced-draft cooling towers, with heat-temperature curves for moist air, and examples illustrating their use.

In a rapidly increasing number of condenser installations, some sort of water-cooling medium becomes a necessity, and, on account of its small space requirements, the forced-draft cooling tower is generally the most feasible. Since apparently little is known of the theory involved and also the practical limitations of the problem, it is the writer's intention to lay down certain principles, substantiated by accurate experimental data, which will enable one to choose intelligently between different designs and estimate the quantities involved.

The physics of water cooling is comparatively simple, and for present purposes is best illustrated by reference to Fig. 1, which represents a typical vertical section of an inclosed tower. Briefly, the operation is as follows:

Hot water enters the tank *a*, is broken up into streams as it leaves the distributing troughs at *b*, and trickles down through the filling *c* where it is still further broken up and comes into contact with the up-going air which enters at *d*. The cooled water is withdrawn from the reservoir *e*.

Inclosed towers are divided into two classes, forced and natural draft, according as the air is forced in at *d* by fans or flows in naturally due to the upward chimney effect when a tall stack is used. The types of towers on the market are identical with the section given in Fig. 1, the distinguishing feature of different manufacturers being merely the arrangement of the distributing system and the kind of filling used. The following analysis holds good for all types.

Water passing through a cooling tower gives up its heat in three ways: First, by radiation through the walls of the tower; second, by direct contact with the up-going air; and third, by evaporation of a part of the water to be cooled. The first item is so small as to be well within the errors of any test and consequently may be regarded as negligible. The amount of cooling due to contact with the out-going air will now be considered. Call this h_1, in B.t.u. per minute. Then

$$h_1 = WS\ (t_2 - t_1);$$

where

W = Pounds of air passing through per minute;
S = Specific heat of air at constant pressure (0.2375);
t_2 = Temperature of the outgoing air;
t_1 = Temperature of the incoming air;

or, as it will be more convenient to express the air in thousands of cubic feet per minute,

$$h_1 = QK\ (t_2 - t_1) \qquad (1)$$

Where Q is the quantity of air in thousands of cubic feet per minute, and the factor K represents the amount of heat required to raise the temperature of 1000 cu.ft. of air through 1 deg. F., taking into account that as the temperature rises, a pound of air increases correspondingly in volume. This value is given by the curve marked K, Fig. 2, and should be taken at the temperature of the outgoing air.

The heat loss represented by h_1 is between 15 and 20 per cent. of the total cooling, depending on atmospheric conditions.

Next consider the third item, the amount of heat abstracted by evaporation of part of the entering water, which represents by far the greater part of the cooling. Obviously, since all the heat lost by the water must be carried away by the air, the amount of this evaporation and consequent cooling will be limited only by the moisture-carrying capacity of the air. A cubic foot of air can contain only a certain amount of moisture, depending on its temperature, and when this maximum condition obtains, the air is said to be saturated at that temperature. When the air actually contains a smaller amount than this, then the ratio of this amount to the maximum possible amount is called the relative humidity, expressed in per cent. When air contains its maximum moisture at any temperature—that is, the humidity is 100 per cent.—if the temperature is decreased moisture will be precipitated; on the other hand, if the temperature is raised, the air will no longer be saturated but will be capable of absorbing a certain additional quantity of water vapor. It is this increasing moisture capacity with increasing temperature that has made the inclosed cooling tower the most efficient means of water cooling; in it the air is heated to the highest possible temperature, approaching that of the inlet water, and consequently evaporates the maximum quantity of moisture. The curve marked *P*, Fig. 2, gives the vapor-carrying capacity of air in pounds per thousand cubic feet at 100 per cent. humidity for different temperatures, the moisture content at any other degree of humidity being obtained by taking the corresponding percentage of these values.

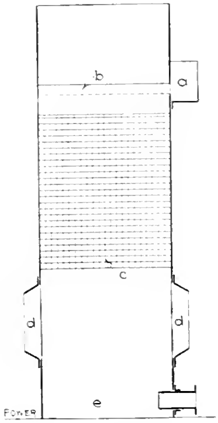


FIG. 1. DIAGRAM OF TYPICAL COOLING TOWER

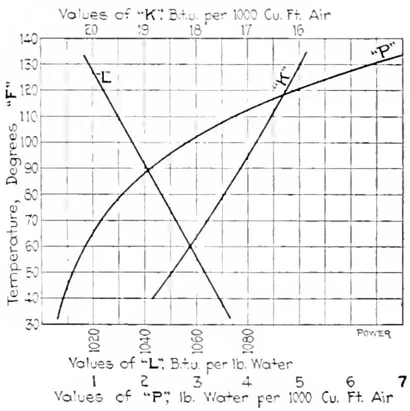


FIG. 2. VALUES OF K, L AND P WITH VARYING TEMPERATURES

Atmospheric air entering a cooling tower is rarely saturated, its degree of humidity being readily obtainable by taking simultaneous readings with the "wet-and-dry-bulb" thermometer and referring to tables in any engineering handbook; but as all cooling-tower estimates are made with direct reference to the humidity and proposals and guarantees are based on this factor, we will not extend our calculations further than this as a starting point. Calling the heat lost by evaporation h_2 and remembering that all the heat lost by the water is gained by the air, the general equation of heat transfer in a cooling tower becomes

$$H = h_1 + h_2 \qquad (2)$$

where,

$$H \text{ (heat lost by the water)} = 8.3\,G\,(T_2 - T_1) \qquad (3)$$

G being the gallons per minute passing through the tower, and T_2 and T_1 the respective temperatures of the incoming and outgoing water.

In order to best illustrate this, the analysis will be applied to test No. 1 in the table of "Tests on a Forced-draft Cooling Tower." The quantities are: $G = 651$; $T_2 = 105$ deg.; $T_1 = 84.7$ deg.; $t_2 = 90$ deg.; $t_1 = 71$ deg.; humidity in = 40 per cent.; humidity out = 100 per cent.

Therefore,

$$H = 8.3\,(651 \times 20.3) = 110{,}000 \textit{ B.t.u. per min.}$$

The B.t.u. by direct heating will be

$$h_1 = QK\,(90 - 71)$$

where Q is the quantity of air in thousands of cubic feet per minute, and K is taken at 90 deg., equal to 17.15 (see Fig. 2). Therefore,

$$h_1 = 17.15 \times 19 \times Q = 326\,Q \qquad (4)$$

The term h_2 is obtained as follows: The moisture content at 71 deg. and 40 per cent. humidity will be $1.16 \times 0.40 = 0.464$ lb., which is the amount of moisture entering the tower with every thousand cubic feet of air. On leaving the tower, the entering air will have increased in volume due to the rise in temperature, so that the quantity of air leaving per minute will be

$$Q\left(\frac{550}{531}\right) = 1.034\,Q$$

where 550 and 531 are the absolute temperatures of the outgoing and incoming air. The moisture content of 1000 cu.ft. at 90 deg. and 100 per cent. humidity is 2.13 lb., the humidity of the outgoing air always being approximately 100 per cent. in a properly designed tower. As there is $1.034\,Q$ thousands of cubic feet leaving the tower, the moisture carried away by the original air that entered the tower will be $2.13 \times 1.034\,Q = 2.205\,Q$. Subtracting from this the moisture held by the air as it entered, gives

$$M = 2.025\,Q - 0.464\,Q = 1.561\,Q \qquad (5)$$

which is the amount of moisture actually evaporated from the water going through the tower, and represents the quantity of makeup water to be supplied per minute.

In order that water may evaporate, it must absorb a certain amount of heat per pound evaporated, called the latent heat of evaporation, the value of which depends upon the temperature at which evaporation takes place; this is given by curve *L*, Fig. 2. As all the moisture is finally heated up to the temperature of the outgoing air, it is correct to use the value of *L* at this temperature. Therefore, the heat absorbed due to evaporation by the air leaving the tower will be $h_2 = 1.561\ Q \times 1041 = 1628\ Q$.

Now by equation (2),

$$H = h_1 + h_2$$

Substituting:

$$110{,}000 = 326\ Q + 1628\ Q$$

and,

$$Q = \frac{110{,}000}{1954} \times 1000 = 56{,}294\ \textit{cu.ft. per min.}$$

By referring to the test, it will be seen that 53,900 cu.ft. of air was actually measured by the anemometer, which is

RESULTS OF TESTS ON A FORCED-DRAFT COOLING TOWER, AVERAGES OF THREE-HOUR READINGS

Gal. per Min.	Temp. In, Deg. F.	Temp. Out, Deg. F.	B.t.u. per Min.	Temp. In, Deg. F.	Humidity In, Per Cent.	Temp. Out, Deg. F.	Humidity Out, Per Cent.	Quantity Cu.Ft. per Min. Measured by Anemometer	Quantity Cu.Ft. per Min. Calculated
651	105	84.7	110,000	71	40	90	100	53,900	53,000
638	107.8	87.5	108,000	72	60	93	100	50,100	51,000
638	112	88.5	124,500	66	60	96	100	51,400	49,400
643	108.5	87	115,000	69	48	92	100	50,200	49,000
640	109.9	90.5	103,400	83	48	95	100	50,600	51,800
*632	116	98	94,800	43	75	101	100	23,500	24,500
*630	135	115.8	102,000	60	73	118	100	17,575	18,250

*Natural draft, fan not running.

NOTE—These tests were conducted with utmost regard as to the accuracy of measurements. The quantities of air per minute were obtained by anemometers being moved back and forth across the top of the tower at regular intervals, and the results were corrected so as to give the actual amount entering the tower. The water was measured both by a venturi meter and a calibrated pitot tube.

or about 10.5 gal. per min. of makeup water must be supplied to compensate for the loss by evaporation.

In order to greatly lessen the foregoing calculations, the "heat-temperature curves for moist air" (Fig. 3) have been compiled with special reference to cooling-tower work. A few remarks on these are necessary. The ordinates represent Fahrenheit temperatures and the abscissas total heat content in B.t.u. per thousand cubic feet of air. This heat content by no means represents an exact "heat potential" at any temperature, and it is only the difference of any two values which has a physical meaning. Neither are the quantities absolutely correct from a theoretical standpoint, as certain factors have been omitted to make the calculation possible; but they will give results which are correct to within 4 or 5 per cent., which is close enough for this class of work. To illustrate the use of the chart, again assume the conditions of test No. 1 in the table. As before, the heat H lost by the water equals 110,000 B.t.u. per min. From the curves the heat content per thousand cubic feet at 90 deg. and 100 per cent. humidity is 3350 B.t.u. The heat content at 71 deg. and 40 per cent. humidity is 1240 B.t.u. Therefore, 3340 — 1250 = 2090 B.t.u. is absorbed per thousand cubic feet passing through the tower, and

$$Q = \frac{110{,}000}{2090} \times 1000 = 52{,}631\ \textit{cu.ft. of air per min.}$$

By simply reversing the process, the terminal temperature may be found if the quantity of air is known. The column marked "Quantity Calculated" in the table was figured

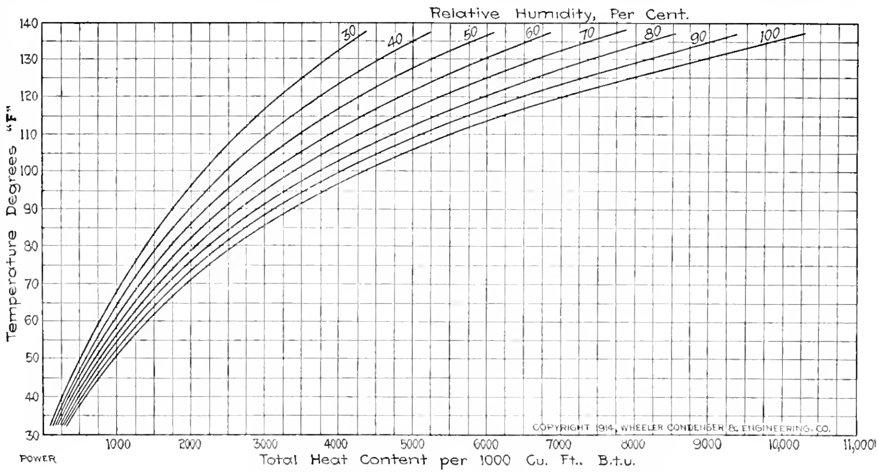


Fig. 3. Heat-Temperature Curves for Moist Air

a variation of only 4 per cent., or as close as might be expected, considering the difficulties involved in this kind of measurement.

By substitution of Q in (4) and (5), we have

$$h_1 = 326 \left(\frac{56{,}200}{1000}\right) = 18{,}321\ \textit{B.t.u. per min.}$$

This is 16.7 per cent. of the total 110,000 B.t.u. given up by the water; that is, approximately 83.3 per cent. of the cooling is due to the evaporation effect alone. Also,

$$M = 1.561 \left(\frac{56{,}200}{1000}\right) = 87.5\ \textit{lb.}$$

from these curves and shows how closely they check with actual results under a wide variety of conditions.

The maximum temperature of the outgoing air is limited by the temperature of the incoming water, and from an examination of curve P, Fig. 2, it is seen that as air increases in temperature, its water-carrying capacity, which represents about 85 per cent. of the total cooling, increases very rapidly. Due to this enormous increase in water absorption at the upper part of the temperature scale, it is evident that the air should leave the tower as near as possible to the temperature of the inlet water, and that an exact knowledge of this terminal difference is essential in figuring the amount of air required for a given duty. In fact, with other conditions remaining the same, the ratio of the temperature of the outgoing air to that of the incoming water represents the real efficiency of any cooling tower. A short calculation will bear this out. Suppose that the air in test No. 1 left at 5 deg. below the incoming water temperature—that is, at 100 deg.: then,

heat content at 100 *deg. and* 100 *per cent. humidity* = 4350 *B.t.u.*

heat content at 71 *deg. and* 40 *per cent. humidity* = 1240 *B.t.u.*

The difference is 3110 B.t.u. Therefore, the air required will be

$$\frac{110{,}000}{3110}(1000) = 35{,}369 \textit{ cu.ft. per min.}$$

as against 52,631 cu.ft. with 15 deg. difference. This means a saving of 34 per cent. in fan power as well as a much lower air velocity, lessening the tendency to cause spray, which is sometimes very objectionable, as well as wasteful. The terminal difference of 15 deg. obtained in the test is by no means average practice, and the results are given merely to show the close agreement of theory and practice in calculating air quantities. In later experiments, made with a view to increasing the efficiency, the quantity of air was not measured. Just how successful these experiments have been is demonstrated by the report of a test recently made on a large installation in the Middle West, consisting of a special Wheeler-Balcke forced-draft tower. The results were as follows, the readings given being the average of a five-hour test:

WATER

Gal. per min.	3200
Temp. in	109 deg.
Temp. out	97 deg.

AIR

Temp. in	91 deg., 59 per cent. humidity.
Temp. out	106 deg., 100 per cent. humidity.

The noticeable feature of these readings is the small difference of 3 deg. between the temperatures of the water in and the air out, giving a terminal efficiency of $\frac{106}{109} = 97$ per cent., which is remarkably high for forced-draft work.

Concerning natural-draft towers, but few remarks are necessary. In general, these will require from four to five times the ground area taken up by a forced-draft tower for the same duty, but where space is available they often find favor on account of requiring no power for operation and needing minimum attention. There are two classes of these towers, the open and the inclosed types. The open type is of cheaper construction, without sides, and admits air throughout its entire height. In the inclosed tower the air is admitted around the base only, and in its upward passage it is entirely protected from the cooling effects of the outside atmosphere. Moreover, due to its low velocity, the air leaves the tower at the same temperature as the inlet water; in fact, repeated tests have shown that the terminal efficiency is practically 100 per cent. In addition to this, the sides give a positive chimney effect, which insures a maximum draft and consequently minimum space requirements for this type of apparatus. In the open tower the quantity of air entering at the bottom is necessarily small, due to the absence of draft effect, and its temperature is prevented from approaching very close to that of the inlet water by a continual inflow of outside air along its entire height. As these towers or racks, as they are sometimes called, lack the positive draft created in an inclosed tower, they are necessarily dependent upon prevailing winds, so that, even in the most advantageous spots, their operation is not reliable nor uniform.

As to guarantees, these usually specify the cooling of a certain amount of water through a fixed temperature range under one definite atmospheric condition (usually 75 deg. and 70 per cent. humidity). Prospective buyers often wish a detailed guarantee for some thirty or forty different conditions of temperature and humidity. This the manufacturer is unwilling to make, as it means waiting for payment until all these different weather conditions happen to prevail. In this connection, the curves of Fig. 3 become useful, especially in a natural-draft system, where the amount of air is not given. To illustrate, suppose a tower is guaranteed to cool 1000 gal. of water per minute from 105 to 85 deg., with the usually assumed air conditions of 75 deg. and 70 per cent. humidity, and that it is required to find the cooling under atmospheric conditions of 70 deg. and 50 per cent. humidity. In a natural-draft tower of the inclosed type, with the conditions of test No. 1, the air would leave at 105 deg. and 100 per cent. humidity. By equation (3)

$$H = 8.3\ (1000)\ (105 - 85) = 166{,}000 \textit{ B.t.u.}$$

By the curves

heat content at 105 *deg. and* 100 *per cent. humidity* = 4850 *B.t.u.*

heat content at 75 *deg. and* 70 *per cent. humidity* = 1800 *B.t.u.*

Heat taken up within the tower = 4850 — 1800 = 3050 B.t.u. Therefore,

$$Q = \frac{166{,}000}{3050}(1000) = 54{,}426 \textit{ cu.ft. per min.}$$

With a given load on the condenser, the heat interchange, the gallons per minute and the cubic feet of air will remain the same; namely, 166,000 B.t.u., 1000 gal. per min. and 54,500 cu.ft. per min. The heat content at 70 deg. and 50 per cent. humidity is 1320 B.t.u. Let X be the heat content of the outgoing air, then:

$$\frac{166{,}000}{X - 1320}(1000) = 54{,}426$$

Therefore,

$$X = 4370 \textit{ B.t.u.}$$

Locating the point 4370 on the 100 per cent. humidity curve, it will be found to correspond to an air temperature of 100 deg. This is also the temperature of the inlet water under the terminal conditions for this type of tower. By equation (3)

$$166{,}000 = 8.3\ (1000)\ (100 - T);$$

whence, T_1 = 80 deg. (outlet-water temperature), representing a total cooling of 20 deg., the same as in the first case. This is obvious when it is considered that both the heat interchange and the gallons per minute remain the same.

By assuming a terminal difference of from 5 to 10 deg., the same method may be applied to a forced-draft system.

For Power Plants at Mines when located near the mine itself an easy and economical method of disposing of the ash is to arrange a tunnel under the fireboxes, with a slope of not less than ⅜ in. to the foot. Connect this with a borehole and wash the ashes down the latter with mine water, where they may be used for flushing abandoned workings if desired.—"Coal Age."

Speed Characteristics of Direct-Current Motors

By Alan M. Bennett

SYNOPSIS—The factors affecting the speed of shunt, series and compound motors under different conditions of load and temperature.

Direct-current motors are classified as shunt, series and compound, depending on the method of field winding employed. While this classification is generally well understood, the speed characteristics of these types under various conditions of load, and while attaining their working temperatures, are not so well known. As these characteristics vary greatly in these types, the behavior of the motor under the above conditions becomes an important factor in determining its fitness for certain classes of work.

All motors are supposed to develop their rated speed at full load after having run a sufficient time to reach maximum temperature; and when the speed of a motor is referred to, it is understood to mean that which obtains under these conditions. Variations from the rated speed occur at two periods in the operation, namely, at the time when the motor is started cold and at no load but after the motor has reached its working temperature. The amount by which the speed under the first condition differs from the rated speed is known as the speed variation of the motor; it is sometimes spoken of as the variation from cold to hot. The change from rated speed under the second condition is known as the regulation of the motor. In each case the departure from rated speed is expressed as a percentage of this speed. Both the speed variation and the regulation may differ in motors of the same class and rating, these characteristics depending on design.

In order to determine the changes in speed under the conditions named it will be necessary to note the changes which take place in the factors that influence the speed. It is a characteristic of the electric motor that, under any condition of load and speed, it takes only the amount of current necessary to develop the torque required to do its work at that speed. This it does automatically in the following manner:

Any motor when running, by reason of its conductors cutting flux, must generate a voltage in opposition to that impressed on the motor terminals, and this will tend to limit the current which would otherwise pass through the armature due to its resistance alone. This voltage is termed the counter electromotive force of the motor, and, like that generated in any dynamo-electric machine, is directly proportional to the speed and the flux. For greater convenience in use, the relation shown by these factors may be written

$$e \propto r.p.m. \times \phi \qquad (1)$$

where

e = Counter electromotive force;

ϕ = Flux.

The above expression may be read: Counter electromotive force varies as the speed and the flux. The value of e is always such that the voltage drop in the motor plus e equals the impressed voltage, or letting I represent the armature current, R the resistance of the motor windings and brush contact, and E the impressed voltage: then

$$e + IR = E, \text{ or } e = E - IR$$

Substituting this value of e in equation (1),

$$(E - IR) \propto r.p.m. \times \phi$$

which by transposition gives,

$$r.p.m. \propto \frac{E - IR}{\phi} \qquad (2)$$

This expression, termed the speed equation of the motor, furnishes a basis for determining changes in the motor speed under any condition. It will be seen that the speed varies directly as the impressed voltage minus the IR drop, and inversely as the flux. Therefore, any condition in the motor operation tending to increase either the IR drop or the flux lowers its speed. Likewise, a decrease in either of these factors raises the speed.

Take the case of a shunt motor starting cold and consider the effect of heating on its speed. The voltage on the field of the motor will be the same as that impressed on its terminals, and whether the motor is loaded or not, the field will receive an amount of current depending on its resistance. This establishes the flux of the motor and fixes its speed. As the field rises in temperature its resistance increases and the field current becomes less. The flux passing through the armature is thus lessened, and from equation (2) it will be seen that the effect must be an increase of speed. This condition continues until the field reaches its final temperature. In commercial motors the speed increase from this source will vary from 4 to 8 per cent., depending on the amount of temperature increase and the degree of saturation of the magnetic circuit. The higher the saturation is carried, the less will be the variation in speed.

Temperature increase of the armature affects the speed slightly by reason of increased IR drop. With the motor starting under load there is a certain amount of drop, determined by the motor current and the resistance of the armature. As the armature heats, this resistance increases and with it the drop. From the speed equation it will be seen that an increase in IR drop means a decrease in speed. The amount of variation from this source is always small, however, averaging approximately 0.7 per cent. While for practical purposes it may be neglected, its effect will be seen to be opposite to that caused by field heating; that is, it tends to lessen the motor speed, whereas field heating increases it.

The regulation of the shunt motor, or its change in speed from full load to no load, while not entirely independent of field action, is caused chiefly by IR drop. This drop increases with the load, being the product of the current taken by the motor and the resistance of the armature and brush contact. Equation (2) shows that the effect of increasing the IR drop is to lower the speed of the motor. Therefore, over the range from no load to full load the motor will drop in speed. Regulation, as stated previously, is measured in percentage of full load speed, and in commercial motors will vary from 4 to 6 per cent.

The effect of the field on regulation is caused by armature reaction. By giving a slight backward shift to the brushes a certain portion of the armature ampere-turns are opposed to the field, which is thus weakened, with the result that the speed is raised. The effect increases with the load and compensates to a certain extent for the decrease in speed caused by the IR drop. This shifting, however, can be done only within limits determined by the sparking of the motor.

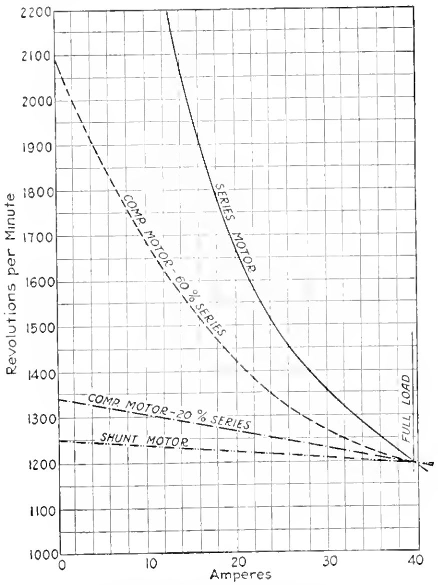


FIG. 1. SPEED CURVES FOR 10-HP. SHUNT, SERIES AND COMPOUND MOTORS

The regulation of motors is most conveniently represented by curves, as in Fig. 1. That for a 10-hp. shunt motor with a 5 per cent. drop in armature winding and brushes shows a decrease in speed from no load to full load of approximately 4.5 per cent.

In the case of the series motor, heating does not play so important a part in its effect on the speed. What variation there is from this source is caused by the IR drop only. As the motor heats, the resistance of the armature and series windings increases, and at constant load the drop increases, with the result that the speed is lowered. This effect is opposite to that in the shunt motor, where the speed increases with increase of temperature. The amount of this variation in the ordinary series motor will approximate 2 per cent., which is small compared to the change in speed caused by a change in load. In the series motor a change in load affects the speed both through the flux and the IR drop. The field current is dependent on the load, being the same as the armature current at all times. The flux passing through the armature being subject to the same variation, the effect on the speed can be seen. Theoretically, the latter would increase from its rated value at full load to infinity at no load. For this reason it is not practical to run series motors without some load in order that they may at all times have a field on them to prevent excessive speed. This is sometimes provided for by winding on a few shunt turns.

The effect of the IR drop due to change of load, while greater in the series than in the shunt motor—because there is a drop in the series winding as well as in the armature and brush contact—will still be small compared to the change caused by flux variation. For this reason the speed of the series motor, particularly below the saturation point of the field, will vary almost in exact inverse ratio with the change in flux and, for all practical purposes, the IR drop need not be taken into account. The speed curve for a series motor is shown in Fig. 1. For the sake of comparison it is made on the basis of the same armature and strength of field as that of the shunt motor whose curve is shown in the same figure. The rapid increase in speed as the load decreases will be noted.

The compound motor, having a field composed of shunt and series windings, partakes somewhat of the characteristics of both the shunt and the series motors. The speed will increase with the heating of the shunt field, as in the case of the shunt-wound machine. Heating of the armature and series field will cause an increased drop in those parts, with a consequent lowering of the speed. However, this drop and the resulting change in speed will be greater than in the shunt motor on account of the added resistance of the series field, the amount depending on the percentage of series windings carried by the motor.

Regulation will depend both on the IR drop and the change in flux due to the action of the series field. Of these two factors, the latter will have the greater effect. In fact, in those cases where the series field strength is in excess of 20 per cent. of the total, the change in flux will practically determine the regulation. As the percentage is increased, the change in speed with the change of load becomes more pronounced and approaches more

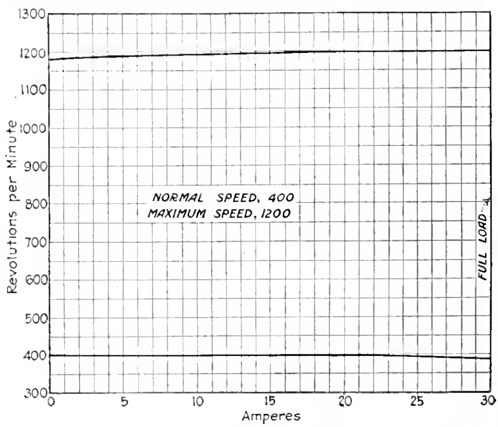


FIG. 2. SPEED CURVES FOR 7½-HP. INTERPOLE SHUNT MOTOR

nearly that of the all-series motor. There is the difference, however, that, due to the shunt field, the compound motor is not deprived of all its flux at no load, and there is not the danger of excessive speed, as in the case of the series motor. In Fig. 1 are shown two speed curves of compound motors, one having 20 per cent. series field, and the other 60 per cent. In the former the regulation is as close as 12 per cent., while in the latter it approaches very nearly that of the series motor. Both of these curves are on the same basis as regards armature and total field strength, as the curve for the shunt motor.

The compound motor, as generally known, has its series field so connected as to strengthen the effect of the shunt field as the load increases, and thus to gain some of the benefits obtained with the series motor, namely, a powerful starting torque and rapid acceleration. By connecting the series winding so that it opposes the shunt field, there is had what is known as the differential motor. This is done to compensate for *IR* drop from no load to full load and render the motor constant in speed over that range. As the load increases, the flux established by the shunt field is lessened by the action of the series, with the result that the speed, instead of falling off due to the *IR* drop, is maintained constant. The differential motor is not widely used, however, on account of other features which are a disadvantage, among these being low starting torque and lack of ability to stand overloads.

In the three regular types of motors described, it has been seen that the *IR* drop causes a falling off in speed from no load to full load, this being the least in the case of the shunt motor. Also, up to certain limits this can be compensated for by shifting the brushes and getting the effect of armature reaction on the field. In a motor fitted with interpoles this same compensation will be noted, only in a more pronounced degree. The action of the interpoles has a weakening effect on the main field similar to that produced by the armature. The result is an increase in speed as the load comes on. This action may even be so exaggerated as to cause a higher speed at full load than at no load, particularly with adjustable-speed motors at their weak field points. There is the difference, however, in the case of the interpole motor that the brushes must be kept at the neutral point on the commutator and brush shifting cannot be taken advantage of.

Fig. 2 shows speed curves for a 7½-hp. interpole shunt motor having a normal speed of 400 r.p.m., and a maximum of 1200 r.p.m. by means of field control. At the low speed it will be noted that the regulation is within 1½ per cent., the speed being practically constant, while with a weak field there is an actual increase of speed from no load to full load.

Powell Automatic and Double-Automatic Stop Valves

The Powell double-automatic stop valve prevents steam from entering a boiler not under pressure from a header, even should a handwheel be operated for this purpose, as the valve cannot be opened by hand until pressure is again raised in the boiler, but it can be closed and screwed down tight by hand. It also prevents steam from leaving the boiler in case of an accident to the pipe line.

The valve disk is of one piece, top and bottom guided at *A* and *B*, Fig. 1, and has a seat on both sides at *C* and *D*. The disk seats at *C* should anything happen on the boiler end and on *D* if there is any trouble on the main steam line.

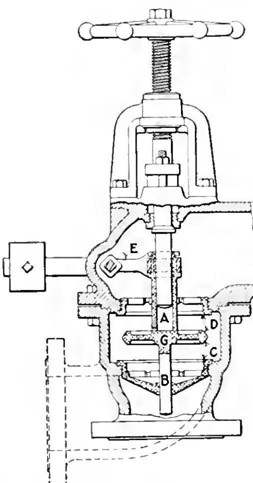


Fig. 1. Side View of Double Stop Valve

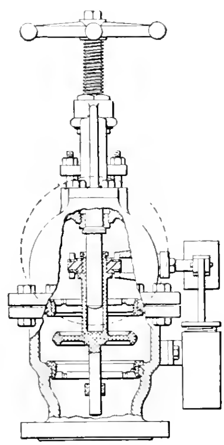


Fig. 2. End View of Double Stop Valve

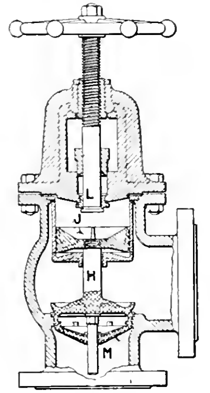


Fig. 3. Section through Single Disk Valve

The upper and lower valve seats are of special nickel composition to resist the corrosive action of the steam. The fork *E* is fastened to the balancing lever stem and holds the valve disk *G* in position, the weight balancing the valve disk. The oil dashpot, Fig. 2, the chamber of which is filled with oil, is to prevent the valve from chattering.

The valve also acts as an automatic equalizing valve between a battery of boilers and can be used as an ordinary stop valve by screwing down the stem onto the disk.

In the automatic stop valve, Fig. 3, the valve disk *H* is attached to the plunger *J*. The disk and plunger are made with but one screw part and are permanently fastened with two sets of screws, making practically one solid piece, guided at both the upper and the lower end. The dashpot fits snugly in the valve body. The rim of the upper part of the disk plunger *J* is grooved to work with a minimum of friction and respond readily to any variation in the pressure. The dashpot has two vent holes at the top and two at the bottom, to allow draining any condensed water that may collect therein. As the lift of the disk is equal to the depth of the dashpot, a full opening of the valve is insured. The height of lift is regulated as desired by raising or lowering the screw stem L.

The seat ring M is made with a guide for the lower part of the valve disk. When necessary, the seat can be readily renewed by inserting a flat tool between the lugs projecting from the circle and unscrewing. This valve will automatically shut off the flow of steam from the header to the boiler in case a tube should burst. It can only be opened by the pressure in the boiler, thus acting as an automatic equalizing valve between the battery of boilers, and also making it impossible to accidentally turn steam into a boiler when it is being cleaned.

These valves are manufactured by the William Powell Co., Cincinnati, Ohio.

Condensation in Hot-Blast Heaters

By James D. White

In the design of a hot-blast heating system it is necessary to know the number of pounds of steam required per minute to heat the specified volume of air through the desired range in temperature. Multiplying the cubic feet of air per minute by the weight of one cubic foot by the specific heat of air and by the temperature rise gives the number of British thermal units required. Dividing this product by the latent heat of steam at the average pressure in the heating coils gives the number of pounds of steam required per minute. Expressing this as a formula:

$$C = \frac{C.F.M. \times W \times S \times T}{L}$$

In which

C = Condensation in pounds of steam per minute;

$C.F.M.$ = Cubic feet of air per minute passing through the heater;

W = Weight of one cubic foot of air in pounds;

S = Specific heat of air;

T = Rise in temperature through the heater;

L = Latent heat of steam.

If steam is purchased from an outside source the formula may be used to determine the service to be provided. If steam is generated in the building it will determine the boiler-horsepower required, or the pounds of exhaust steam from the engines or turbines.

The main supply pipe to hot-blast heaters is often made too small, due to the fact that the actual requirements are not carefully considered. A rule of thumb common among steam fitters is to make the supply pipe equal in size to that required for direct radiation of five times the surface contained in the hot-blast heater. Cast-iron direct radiation for low-pressure steam will transmit about 250 B.t.u. per sq.ft. per hr. On the rule of thumb basis this would mean a transmission of 1250 B.t.u. per sq.ft. per hr. for the hot-blast heater. This transmission rate is correct for deep heaters with low velocities over the surface. For shallow heaters or high velocities this rate may run as high as 2500 B.t.u. per sq.ft. per hr., showing the error that may be made by the use of the above rule.

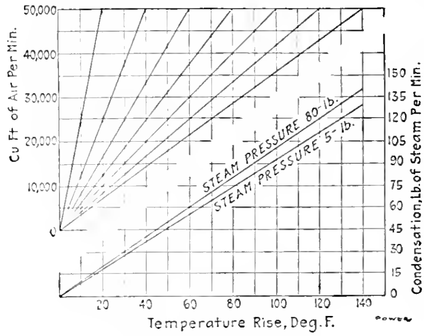
The following values are taken from published data regarding a well known type of hot-blast heater:

Number of Sections	Temperature Rise
1	32
2	59
3	82
4	100
5	116
6	129

From an inspection of the above values it will be noted that nearly one-fourth of the total heat rise is obtained in the first section of the heater. Since condensation is directly proportional to heat rise it follows that nearly one-fourth of the total steam required by a heater will be condensed in the first section.

It is customary to tap all sections of a hot-blast heater for the same size of pipe, this size being ample for the first section of the heater. There appear to be no good reason for this since a substantial saving could be made by tapping the sections in proportion to their steam requirements. The amount of condensation as calculated above is also useful in determining the size of steam trap or pump for returning the water of condensation back to the boiler.

The standard curves of hot-blast heater manufacturers are usually based on the heat rise with velocities of air



Condensation Curves

measured at a standard temperature of 70 deg. This temperature of air has been assumed for the volumes of air as given in the condensation curves presented herewith.

As an example, assume that it is desired to know the pounds of steam required to heat 40,000 cu.ft. of air per minute from zero to 100 deg. with steam at 5 lb. pressure. Starting at the line in the upper left-hand corner of the diagram corresponding to 40,000, draw a horizontal line until it intersects the 100-deg. line. Drop a vertical line intersecting the steam-pressure curve; then draw a horizontal to the right and find that the condensation is $74\frac{1}{4}$ lb. of steam per minute.

Safety Suggestions—If any employee shows signs of carelessness, tell him about it. If he persists, report him. Otherwise you may be the one to receive an injury through his negligence. Careless men are a menace to all around the power station.

Don't forget the other fellow. Careful men are hurt and killed every hour through the negligence of others. Better be safe than sorry.

Don't fail to look up occasionally; there is danger from above as well as below.

Don't fail to have any defective tools or equipment repaired at once.

Always treat conductors and switches as though they were alive.—"Aera."

Editorials

Obstructive Legislation

Large power interests, hiding behind the plea of states' rights, are attempting to defeat the Ferris water-power bill by creating a situation that will prevent the measure coming to a vote in the Senate before March 4, and there is growing apprehension that the same interests which have prevented conservation legislation for the last ten years will still be able this year to keep the natural resources in the public domain out of use and development.

It is a big game for big stakes that large financial and political interests are playing. Hydro-electric power is still in its infancy. Its possibilities are hardly to be conjectured. Even under present conditions of development, there is enough potential water power in the United States to take the place of the total coal consumption. In some parts of the country and under some conditions of construction, production of power from coal entails a lower installation cost than hydro-electric production, even where water power is available. Constantly improving methods of hydro-electric development and improving methods of power transmission, however, make it impossible for anyone to say what this water power will be worth or what its development will cost in the next decade or two. When the diminishing supply and increasing price of coal are considered, water power assumes an importance that can hardly be over-estimated.

So far-reaching were the plans and so rapid has been the progress of the hydro-electric monopoly that in 1913 twenty companies or groups of financial interests, all more or less closely interrelated, had acquired control of 2,710,866 of the 7,000,000 horsepower developed in the United States, and these same combinations also controlled 3,556,500 undeveloped horsepower. In California one corporation owns 27 per cent. of the total developed horsepower in the state, and two groups own 57 per cent. of the total development; in Oregon 90 per cent. of the developed horsepower is controlled by these allied groups.

With a few exceptions, the power sites not remaining in the ownership of the Federal Government have passed into private ownership in perpetuity. State governments generally have been notoriously profligate in giving away public property and franchises for small return or for no return, and until recent years, generally with no provision for regulation. In many sections state governments, to induce development and industries, have made it a rule not only to give away such valuable public assets, without price or restriction, but also to exempt such grants or gifts from taxation for a longer or shorter time.

Conservative estimates place the total available water power in the United States at 25,000,000 horsepower, of which 7,000,000 horsepower has been developed. Of the undeveloped water powers, about three-quarters are owned by "Uncle Sam," the power sites being located on public lands. Control and monopoly of this undeveloped power are the stake for which the big interests are playing.

To prevent more of the remaining water powers being grabbed by private monopoly through fraud or misrepresentation, the Government several years ago located all the valuable power sites in the public domain, and the President withdrew them from entry. Most of them are still withdrawn. Special interests protested, but the prevailing public sentiment was in favor of conservation, and then the interests changed their tune. Now they are all for states' rights. They are for conservation, and they are for regulation, but they want the Government to give the lands to the states and let the states do the regulating. The reason is that they can do business more profitably with state governments, governors, legislatures and utility commissioners than they can with the President, Cabinet officers, Congress and the Interstate Commerce Commission.

Secretary Lane, who is a Western man and who wants to see the resources of the West developed, has been backing legislation to encourage the use of water power and the mining of coal, oil, phosphates and potash under a leasing system. President Wilson supports this policy. The House of Representatives has passed the Adamson and the Ferris water-power bills, drawn along these lines. The Ferris bill provides that power sites may be leased for a term of not more than fifty years, with a twenty-year renewal of the lease at the end of the fifty-year period, on terms to be fixed by the Secretary of the Interior. At any time after the end of fifty years, the Government would have the right to take over the power plants by paying their fair value to the owners, and thereafter to either operate the plants as government institutions, or to sell or lease them to municipalities, states or individuals.

In support of this legislation, the President, Secretary Lane, such conservationists as Gifford Pinchot, and others have urged that a fifty-year permit would enable power companies to enlist capital and finance their operations profitably, giving the communities the advantage of early development and insuring against monopoly and extortion, with a reversion of these valuable rights to the public at the end of the franchise term.

Some of the big power interests have agreed to this program; others are opposing it, some of them openly, but more of them under cover. Senators who for years have been notoriously representative of big interests and special privileges are opposing the bill. The opposition, however, is subtle. It is not openly in opposition to limited franchises or regulation. To defeat the legislation, the old Civil War issue of states' rights has been dug up. Corporation lawyers, bankers, politicians and lobbyists are busy telling the Senate that the public lands, including the mineral resources and water powers, should be given to the states in which they are located.

The corporations and the politicians know what the states have done in the past with their resources and what they may reasonably be expected to do in the future. State utility commissions generally have few powers, and do not exercise them. Some of the Western states have no utility commissions and have never made any pretense of regulating anything. Mineral lands, water powers and similar natural resources belonging to these states have often been considered fair loot for anybody who could get them.

There are votes enough in the Senate to pass the bill if it can be got to a vote, but the opponents are prepared to play all the legislative tricks they know to prevent this. If they can stave off a vote until after March 4, the bill will then be dead, and a new bill will have to be passed by the House, which means more years of delay and disuse for the water power.

Purchasing Coal

The question of the ultimate advantage of purchasing coal on the B.t.u. basis is raised by Mr. Brownell on page 131 of this issue.

It is true that all of the coal mined must, or should, be used as fuel, and if the dealer cannot market inferior stuff in one place he will send it to some other place. This is, of course, an unavoidable condition of affairs to the dealer, and may be entirely satisfactory to the user so long as he is equipped to handle such fuel economically; but the purchaser or user should know what he is paying for or trying to make steam with. The crux of the whole matter is as the pure-food advocate, Dr. Wiley, has often said—he has no desire to dictate to or to prevent any individual from using adulterated foodstuff, but he does want him to have every opportunity of knowing what he is using and what the probable effect will be. Likewise in the use of coal, the consumer should know as much as possible of the characteristics of the available fuel supply in order to modify his furnace and equipment to suit the conditions. The total cost in fuel, labor and upkeep of evaporating water is the basis of comparison and the final test of the value of fuels. If the consumer has no alternative he must take what he can get and make the best of it.

13.8 Kw. per Boiler Horsepower

At a recent lecture by W. A. Blonck, of Chicago, before the New York Electrical Society, the interesting information was given out by Mr. Pigott, of the Interborough Rapid Transit Co., that eight boilers of 520 horsepower each are to serve 30,000-kilowatt turbo-generator capacity. This gives 7.21 kilowatts per boiler horsepower, which is considerably higher than that heretofore practiced. The Connors Creek station of the Detroit Edison Co. was designed so that in emergencies 5.65 kilowatts per boiler horsepower might be attained. This was the highest ratio heretofore.

The statement that so and so many kilowatts of output is obtained from a boiler horsepower does not tell much about the rating at which the boiler must be run unless the water rate of the prime mover is given, because the ratio is dependent both upon boiler rating or capacity and the steam consumption of the unit or units served by the boilers. The ratio is, however, an indication of the advance in boiler practice and turbine economy.

In this respect the Interborough's Seventy-fourth Street plant is interesting. The steam consumption of the 30,000-kilowatt turbine, served by eight 520-horsepower boilers, is 11.25 pounds at normal load. This gives 3.06 kilowatts per boiler horsepower at the normal rating of the boilers. So at a little over 200 per cent. of rating these eight boilers carry the load of 30,000 kilowatts, giving 7.21 kilowatts per boiler horsepower. A statement to us by Mr. Stott, superintendent of motive power for the Interborough Rapid Transit Co., that there might be times when it would be necessary to operate the boilers at 450 per cent. of rating for short periods, as in emergencies, is of much interest here. A boiler rating of 450 per cent. is possible, for with a clean and well designed boiler and furnace, the only limit to capacity is the amount of fuel that can be burned on the grate. As 3.06 kilowatts per boiler horsepower is obtained at 200 per cent. of rating, at 450 per cent. 13.8 kilowatts could be had per boiler horsepower.

James Watt must turn over in his grave at this.

Summary of Boiler Accidents

The list of boiler explosions which occurred during the first half of the year 1914 contains 320 as the total number. Of the number mentioned in our Jan. 5 issue, 20 are not included, because of denials on further inquiry that explosions had occurred. It frequently happens that in reply to our inquiry to the parties concerned a complete denial is received, but later information verifies the original report. This, in some cases, may have been due to an interpretation of the term "explosion" as a violent disruption of the body of the vessel used to generate steam. In general, for the purpose of tabulation the word is taken to apply to any failure which even temporarily puts the boiler out of use, including tube, header and blowoff-pipe failures. The nature of the failure is stated in every case in which the facts are obtainable. These statements are not always as full and satisfactory as might be desired.

The greatest number of accidents from any one cause was due to tube failures, but cast-iron header failures show an alarmingly increased percentage. When it is considered that from four to ten or more tubes are connected to a pair of headers and that a number of types of water-tube boilers in use are not so constructed, the total header failures compared with tubes is enormous.

Next in number comes the blowoff pipe. Considering the severe service and exposure of these pipes it is not surprising that they should deteriorate rapidly. This being generally recognized, it is evident that this part of the boiler should receive more careful and frequent scrutiny and should be replaced on the first appearance of weakness or danger. Cast-iron heating or domestic boilers are shown to be frequently neglected and mismanaged. In view of the damage done (in some cases well up in the thousands) when one of these boilers explodes, it cannot be said that they are receiving the inspection and supervision they should have. Even kitchen ranges and boilers have contributed a considerable amount to the total wreckage. A comparison of the totals for the first half of 1913 with those for the same period in 1914 follows:

Total number of accidents, 264 (1913), against 320 (1914), with a loss of life of 53 against 120, and injured, 192 against 240. The monetary loss was $193,000 (1913) and $246,000 (1914), respectively, with an average for those for which estimates were obtainable of approximately $1330 against $3000. Tube failures appear to have been more numerous during the year 1913, as 70 are shown, while a year later only 60 are reported. Header failures were only an incident, however, in 1913, while 30 occurred in 1914. Blowoff accidents stand 13 to 17, and cast-iron heating boilers 33 to 70 for the two periods, respectively.

Correspondence

Purchasing Coal

The writer recently had occasion to condemn a car of No. 1 buckwheat coal on account of excessive slate and screenings. A representative of the coal company arrived a few days later, and upon screening a 50-lb. sample from the car he found 12 per cent. rice or barley coal. A 10-lb. sample showed 14 per cent. slate.

The inspector passed the car, as he said the percentage was well within the allowance. Upon being pressed for some definite understanding as to what we were forced to accept, he made the statement that the coal company allowed itself 15 per cent. screenings and 15 per cent. slate. He was then asked if his company sold anthracite on a heat-unit basis. He replied that it would not sell coal on such a contract. Consequently, if the slate test is the only one which is acceptable, it becomes the test we are forced to use.

The large consumer situated on a navigable stream or where he can be served by more than one railroad can buy his coal on the heat basis, and he has this advantage over the smaller consumer who can obtain coal from only one railroad.

After all, does it pay? Is it to the consumer's advantage? Buying coal on a B.t.u. basis resolves itself into a matter of service. The consumer pays for that service whether he, the coal company or some disinterested party analyzes the coal, and when the cost of this service is put over against the gain, will not the apparent saving effected be wiped out?

R. A. Brownell.

Middletown, N. Y

Concrete for Furnace Lining

A concrete that could be used successfully as a boiler-furnace lining would do much to reduce the maintenance cost of the furnace. The largest item in furnace maintenance is labor, and when the labor is inexperienced, as when a bricklayer who never laid firebrick is engaged for the job and insists on laying the brick with a $\frac{3}{16}$-in. joint, the cost of upkeep is indeed high.

A concrete containing limestone would be unfit for the purpose because limestone calcines at a comparatively low temperature. The writer's experience with concrete furnace lining is limited to a test in which two patches 18 in. square were made, one on each side of the furnace, one patch being of slag concrete and the other of cinders. Neither proved satisfactory, probably because the concrete was not given sufficient time to set, the boilers being put back in service within 36 hours.

A concrete that may fulfill the requirements could be made of portland-cement clinker, graded from fine to coarse so as to make unnecessary the addition of sand. This concrete should be made with a minimum of water. Such material is sometimes used as a lining for cement kilns. Engineers in cement plants may be able to give some information on the use of clinker concrete in boiler furnaces.

Could boiler settings be made of concrete a great convenience would be effected; the two-inch air space is no longer fashionable, and the form work being simplified thereby, all the work could be done by the boiler-room force, thus eliminating the bricklayer.

C. O. Sandstrom.

Kansas City, Mo.

I have tried several different mixtures of cement and sand with hard-coal ash, soft-coal ash, flue cinder and salt for furnace lining, bridge-wall and fire-door arches. A mixture of one part cement, three parts hard-coal ash, one part fireclay, one-half as much sand as cement and about one per cent. salt made a bridge-wall that outlasted firebrick. For lining, I have been able to get a cement mixture that would outlast a good firebrick lining when properly laid, if there is time to let the wall harden thoroughly before it is necessary to start the fire.

The mixture described in Power, Dec. 15, p. 840—i.e., one of cement to five of hard-coal ash and one-half of sand—ought to be good, but I would add about one per cent. of salt to the mixture. When the wall gets hot the salt and sand will tend to melt and will fill up the pores and cracks showing in the cement.

For fire-door arches about the same conditions prevail. One part of cement, one of sand and five of hard-coal ash or broken soft-coal cinders or clinkers holds up better than firebrick set with fireclay. It is necessary, however, to let the arch have at least four weeks to set before putting the furnace into operation, and in many cases this is not possible.

A. A. Blanchard.

Oxford, N. J.

Graphite in Boilers

Much has been said in Power relative to the use of graphite in boilers. I first used graphite in a plant having four 300-hp. water-tube boilers. No compounds had been used in this plant and the tubes were in fair condition. It required, however, from twelve to fifteen minutes to get through a tube with a turbine cleaner, maintaining 180 lb. water pressure at the turbine, and occasionally we encountered tubes which required twenty to thirty minutes, but fifteen was a fair average. Before using graphite we turbined the boilers every ninety days, and this practice was followed for about nine months after it had been in use.

Notwithstanding that the output of the plant was increased more than 30 per cent. during the first nine months' use of graphite, we were enabled to increase the continuous runs of the boilers. Records show that two boilers were operated for 139 and 143 days, respectively, without turbining any of the tubes. Then they were opened and turbined throughout without difficulty. Furthermore, we were able to get through most of the tubes in less than eight minutes for each. Graphite did not show favorable signs until it had been in use more than five months and did not get in any good work until we had used it for about seven months; at this time one and one-half barrels had been used.

At the end of seven months we began loosening large pieces of scale in the steam drums. The writer put two good men in the drums for over two days, who succeeded in getting off large quantities of scale which ranged from 1/8 to 5/16 in. thick.

In my next plant I found dirty boilers and lost no time in ordering a turbine cleaner and a barrel of graphite. It required more than five months to get the cleaner, and this gave the graphite a chance to act before its arrival. I find that graphite will soften incrustation and loosen the heavy scale in the drums or on the sheets; it is, however, essential that mechanical methods be employed to remove the scale.

If maximum results are to be realized from the use of graphite, the boilers must be cooled down thoroughly before they are opened, and the drums must be washed immediately with a large hose and high water pressure. The scale will be soft mud when wet, but it will get hard when it dries.

It is much easier to wash the surfaces and then scrape them than to allow the accumulation to solidify and then pound it loose with the peen of a hammer. Do not take the tube caps or the man-heads off and allow a boiler to stand over night before washing and turbining. Take the tube caps off and put the turbine through the tubes as fast as possible. Then if any scale of consequence still remains, replace the cutters on the turbine cleaner with new ones and go through the tubes carefully the next day.

WALDO WEAVER.

Emporia, Kan.

Underfeed Stokers

In Osborn Monnett's article, "Underfeed Stokers," in the Dec. 15 issue of POWER, there is illustrated a "typical setting of American Stoker" under a return-tubular boiler. The stoker shown is not the American Stoker, but is the Type "D" of the Combustion Engineering Corporation. This stoker was formerly made by the American Stoker Co., and the drawing from which the illustration was made is of an installation made by that company. Mr. Monnett's assumption was natural, but it is regretted that he did not have the data on the Type "E" stoker for his article.

The Type "D" stoker is designed primarily for internally fired boilers with cylindrical or corrugated furnaces, but it may be applied to other boilers of 100- and 150-hp. capacity.

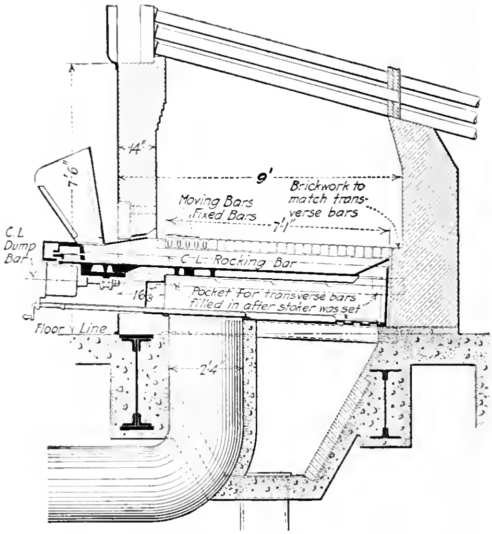
For boilers of 200 hp. and upward, the Type "E" stoker of the Combustion Engineering Corporation will effectually prevent smoke at ratings of 150 and 200 per cent. But one retort is installed in furnaces up to 12½ ft. wide.

The illustration shows a typical setting under a horizontal water-tube boiler. For vertically baffled boilers the minimum height of setting is 7 ft. 6 in. from the floor line to the header, and on Eastern coal of 16 to 26 per cent. volatile matter, 50 lb. per sq.ft. of furnace area may be burned without smoke. This is equivalent to 175 to 225 per cent. of the boiler rating. For Western coals of 30 to 40 per cent. volatile matter the height of the setting should be 8 ft. or more for similar results. There will, of course, be proportionately larger grate surface for Western coal if high ratings are required.

Operating

When starting fires with a Type "E" stoker, fill the retort and over-grates with coal about two inches deep, throw several shovelfuls of live coal along the retort and on the grates and start the blower slowly, increasing the speed as the coal becomes ignited. As soon as the coal is well ignited, start the stoker, increasing the coal feed and the air supply as required.

The fires should not be carried at over 8 to 12 in. in thickness with coking coal, or 4 to 8 in. with free-burning coal. The distribution of coal is uniform, making it unnecessary to poke, slice or rake the fires. The auto-



TYPE "E" STOKER UNDER A WATER-TUBE BOILER

matic regulation will take care of any variations in load between 100 and 200 per cent. of rating.

When ashes have accumulated on the dump trays to such a depth that the trays will not hold more, they should be dumped. Slow down the stoker slightly and burn out all coke on the trays, using forced draft if necessary. Drop the dump trays and if any clinker has adhered to the side walls or overhangs the ends of the fire bars it can easily be removed with a slice bar. Then restore the trays to the running position and operate the stoker a little faster than normal for a few moments; then throw in the automatic. Ashes should be dumped every two to four hours under ordinary conditions. The ash on the fire bars should not be disturbed.

When banking fires, shut off the air and feed in enough coal to make the required bank, then close the fire-doors and damper. If necessary the bank may be replenished by feeding in more coal.

To start from a banked fire, dump the ash, open the air gate a very little for a minute, break any large lumps of coke and then start the stoker, increasing the coal feed and air pressure as required. To kill the fire in case of accident, shut off the air, drop the dumps and feed coal to maximum capacity. Turn a hose into the ashpit to quench the live coal dumped.

JOHN VAN BRUNT,
Combustion Engineering Corporation.
New York City.

Centrifugal Pumps for Boiler-Feed Service

We have read with interest the extract from a paper by E. S. Adams, in the Dec. 29 issue, p. 934. From our experience we are inclined to disagree with this statement which appears on page 935:

> While this is especially true with motor-driven pumps, it also applies to turbine-driven pumps, as a serious overload (due to the enormously increased capacities which are obtained on some designs of pumps when the pressure is dropped) sometimes destroys the turbine.

The condition mentioned by Mr. Adams is impossible, as an overload beyond the designed capacity of the turbine would only cause it to slow down. We would be interested to learn of any turbine-driven installations where the action referred to has apparently taken place.

RAINES KESSLER,
Terry Steam Turbine Co.
Hartford, Conn.

Thick Boiler Plates

The article by S. F. Jeter in the issue of Dec. 22, p. 884, recalls to the writer a battery of horizontal tubular boilers in which the plates are $\frac{23}{32}$ in. thick (just $\frac{1}{32}$ under $\frac{3}{4}$ in.). At the girth seams the plates are reduced to $\frac{7}{16}$ in. in a way similar to that shown in Fig. 2 in Mr. Jeter's article, except that in this case, and in fact in all cases of heavy fire sheets that have come to my notice, both the inside and the outside plates have been reduced in the manner shown in Fig. 1 herewith. These boilers have been in service day and night for 12 years. Stokers are used and a steam pressure of 145 lb. is carried. The

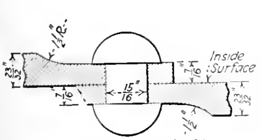


FIG. 1. GIRTH SEAM BELOW FIRE-LINE

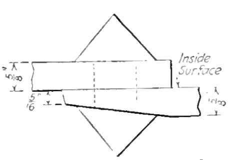


FIG. 2. INDICATING POINT OF OVERHEATING BY SCARFING OUTER SHEET ONLY

ONE FORM FOUND SATISFACTORY: THE OTHER QUESTIONED

service required of the boilers is much more severe than in the average plant, yet there has never been a leak or a fire crack at the girth seams.

Plates $\frac{23}{32}$ in. thick are the heaviest I have known in an externally fired boiler, and I have seen them with $\frac{9}{16}$-in. plates with the thickness of each plate reduced at the girth seams to about half the original thickness and none of them ever developed defects at this seam.

As Mr. Jeter points out in his Fig. 4, there is a tendency to crystallize at the calking edge when exposed to high temperatures. Crystallization of the plate at the point indicated might result in a fire crack extending from the edge of the outside sheet to the rivet hole, not a very serious defect and one easily repaired. In his Fig. 5 he suggests a method which would no doubt overcome the tendency to overheat at the edge of the plate, but which would transfer the crystallization to a point farther back, or about as shown in Fig. 2 herewith. A fire crack developing at this point would open into the solid plate.

Experiment or practice has not yet determined the heaviest plate practicable in an externally fired boiler. We do not know, however, that fire sheets $\frac{1}{2}$ in. thick stand up well under heavy firing with two full thicknesses of plate at the girth seam and that plates $\frac{5}{8}$ in. thick will fire-crack with a double thickness of plate under comparatively easy conditions. The limit of thickness at the girth seam may or may not lie within this range, but we do know that the girth seam shown in Fig. 1 has stood up well under severe conditions for a number of years, and the thickness of the joint is less than that made by two $\frac{1}{2}$-in. plates, and that the tendency to crystallize at the calked edge due to high temperatures is less than it would be in a girth seam with a total thickness of 1 in. through the joint.

THOMAS GRIMES.
Houghs Neck, Mass.

Cost of Steam

The cost of steam regardless of its use is an important matter to every live engineer. The information on this subject which occasionally appears is interesting and valuable, as it shows us what the other fellow is doing with his equipment, fuel, etc., and enables us to compare notes. I think we can stand a generous amount of steam cost data, but to be of maximum value the reports should be fully and accurately comparable. Most of them simply show that A has a small plant and pays $4 a ton for coal, and give a figure on the cost of steam per thousand pounds, based on the cost of labor and coal only.

B has a different plant, equipped with all of the latest devices for producing steam cheaply, and is able to buy and use a low-grade coal which gives an equivalent heat value. He therefore produces steam for much less money than A, which makes A feel like thirty cents when he sees it. Of course, we care nothing about A's feelings. Besides, it may wake him up and do him good. There is doubt, however, whether B has a right to feel so chesty. We have but part of the actual cost to A and perhaps less information from B, therefore, a fair comparison is out of the question.

It may be satisfactory enough to charge only coal and labor as the cost of steam as a means of comparing different coals, or for other comparisons within that plant, but when an attempt is made to get at the actual cost of steam or compare one plant's results with those of another, the need of reducing the results to a common basis is evident. This means a full description of the equipment, repairs, interest on the investment, insurance, taxes and depreciation. The cost of operating draft machinery, stokers, etc., should be included with the cost of labor and fuel. Until this is done no one can discuss relative steam costs intelligently. Any useful information is acceptable, but full and exact information is needed.

H. L. STRONG.
Yarmouthville, Maine.

Shaft Coupling Made into a Belt Pulley

While employed at Fort Yuma Indian School, I needed a six-inch belt pulley for a wood saw. As some readers may know, getting such supplies on an Indian reservation is a long and trying ordeal. Therefore, I used a flange coupling keyed to the saw mandrel, with thick planks bolted between and sawed to the same circle as the flanges. This served the purpose while we sawed 100 cords of wood for our winter's supply.

J. E. STROTHER.

Rock Island, Ill.

Calculating How to Cut a Manhole Gasket

The following questions were asked me recently in a steam-engineer's license examination. I also give my answers:

Could you cut a manhole gasket if the manhole head was not convenient to be used and do it correctly?

Yes, if I knew the distance between the two foci of the ellipse.

Given the long and the short diameters, how would you find the distance between the two foci?

Square half the long diameter, from it subtract the square of half the short diameter; the square root of the remainder is half the distance between the two foci.

I spent three days hunting for the answer to the last question, and I found another item that helps to show why the above answer is true.

To locate the two foci of an ellipse graphically, take one end of the short diameter as a center and half the long diameter as a radius and describe arcs intersecting the long diameter each side of the short diameter. These points of intersection are the two foci.

F. C. WIRES.

Seattle, Wash.

New vs. Second-Hand Machinery

M. E. Griffin's experience (POWER, Dec. 22, p. 889) with the man who wanted an exceptionally economical engine and finally purchased an old second-hand one reminds me of some of my own experiences with would-be cheap-power-plant owners.

A man in southern Florida hired me to install a three-ton ice machine and set up a new (?) sawmill. When I arrived I found an old belted compressor rated at three tons, but which its former owners had never been able to drive past one ton of ice in 24 hours, with a one-ton capacity brine tank and a cold-storage room taking approximately one ton of refrigeration for 24 hours, an old internally fired boiler all pitted and having several soft patches on it, also an old locomotive-type boiler with an engine mounted on it.

I set up the outfit, but refused to run it, and the last I heard it was still idle because it is cheaper to buy ice and pay freight on it than to make it with the outfit. The sawmill part of the equipment was a little better, and after getting a new boiler the owner finally did get a man to run it.

I was engaged another time as a millwright and master mechanic for a lumber company, the president and superintendent of which were experienced millwrights. The boiler and engine were too small, so they made up their minds to install larger ones. I advised them to get a new boiler and engine and get them from a reliable manufacturer, but they decided this was too expensive and finally bought a second-hand Scotch boiler that had been run about six months and then replaced by a return-tubular boiler of the same rated capacity, because the Scotch boiler would not do the work required.

I begged both the president and the superintendent not to take the boiler, as it was entirely unsuited to their work and to the fuel that they must use, and pointed out other defects, but they got it and the results turned out as I said; the furnace was too small to burn the fuel, and after trying several kinds of grates they finally inclosed the boiler in a brick setting, making virtually a double furnace. The outfit cost $250 more when finished than a new return-tubular boiler with a full brick setting would have cost.

The engine they bought was an old sawmill engine which had been over twenty years in service and through two fires. They paid $150 for it and $300 to have it repaired. A better engine could have been purchased new for less than $500, and would have been an engine, not a junk heap.

Why men will pay good money for worthless piles of scrap iron in the shape of second-hand engines and boilers I could never understand, for new outfits are always cheaper in the end.

A. A. BLANCHARD.

Oxford, N. J.

Testing Out Automatic Safety Devices

The editorial on "Testing Out Automatic Safety Devices," in the Dec. 1 issue, reminded me of a plant in which I was oiler. The engines were cross-compound Corliss, with the governor on the low-pressure side and a safety stop valve in the high-pressure steam pipe, operated by fly balls on the high-pressure side. These fly balls were called the high-pressure governor by the engineers.

I wanted to know if, in case of overspeed, the engineer or oiler could operate the valve. I was told yes, and that the automatic stop could be used instead of the throttle at shutting-down time.

I suggested that we try it at the first chance, and we did. Did the automatic safety-device work? Sure it worked, but not until we had spent several days scraping off burned oil and repacking.

G. D. Crain says in the same issue that "owners of larger plants have their boilers insured, which results in high-grade inspection." I beg to differ. I know of boilers that were insured and regularly inspected and, just as regularly reported in good condition; I also know that many of the tubes were packed solid with scale.

The editorial already mentioned says, "He is a wise engineer who will use those safety devices which lend themselves to hand as well as automatic control in handling the machinery which they should safeguard."

He also is a wise engineer who will inspect his own boilers, no matter how many inspectors may do it besides.

Chicago, Ill. W. H. MACKING.

Inquiries of General Interest

Grate Area with Mechanical Stokers—For a given boiler capacity, why is less grate area required for mechanical stokers than for hand-fired grates?

H. C.

The motion of the mechanical stoker maintains a cleaner fire by continuously disturbing the film of ash which is formed on the burning coal, so that the rate of combustion is greater per square foot of grate.

Causes of Pump Running Lame—What causes a duplex pump to run lame—i.e., the strokes on one side are shorter in length of time than those of the other?

B. L.

The slower-running side may have a leaky steam piston or the resistances of the water cylinders may be different, as from a worn pump valve, a leaky water piston or leaky valves on the quicker-running side or tighter water piston or stuffing-boxes on the slower-running side. When such faults have been corrected the lost motion of the steam valves should be adjusted to obtain the desired equality of strokes.

Using Soda Ash for Removal of Scale—Will a boiler be injured by using soda ash in the following manner? Before washing the boiler put in about 40 lb. of the soda ash, again close the boiler, and with the water a little above working level, boil slowly for a few hours, and after allowing the boiler to stand for three or four days, wash thoroughly.

R. G. T.

There should be no injurious results if care is taken to thoroughly wash out all traces of sludge from the try-cock and water-column connection and the soda solution is not permitted to enter the safety valve, for upon drying it would be likely to cement the valve to its seat.

Pipe Sizes for Hot-Water Heating—What is the rule for determining the sizes of supply and return pipes for a gravity hot-water heating apparatus with direct radiation?

J. M.

As there is no sensible change in bulk between the supply and the return water, the supply and return pipes should be of the same diameter. With ordinary conditions, and where the supply or return pipe is less than 200 ft. in length, it is a good practical rule to allow one pipe size greater than the square root of the number of square feet of radiating surface, divided by 9 for the first story, by 10 for the second story, and by 11 for the third story of a building.

Relative Volumes of Water and Steam—What are the relative volumes of a pound of water at 212 deg. F. and a pound of steam at atmospheric pressure?

W. R.

A cubic foot of water at 212 deg. F. weighs 59.833 lb., and one pound occupies a space of

$$\frac{1}{59.833} = 0.0167 \text{ cu.ft.}$$

while one pound of dry saturated steam at atmospheric pressure (14.7 lb. per sq.in.) occupies a space of 26.79 cu.ft., which is

$$\frac{26.79}{0.0167} = 1604.19 \text{ times the space occupied by the water.}$$

Indicated, Brake and Friction Horsepower—What is meant by indicated, brake and friction horsepower of a reciprocating engine?

S. C. M.

Indicated horsepower (abbreviated i.hp.) is the power delivered to the piston by the steam or other working fluid which is employed for moving the piston, and is so called because the effective pressure is usually determined by use of a steam-engine indicator. Brake horsepower (abbreviated b.hp.) is the power delivered by the engine exclusive of the power wasted in overcoming the friction of its moving parts. The brake horsepower is therefore always less than the indicated horsepower, the difference being the power required to overcome the friction of the engine. This difference is sometimes called the friction horsepower.

Capacity of Triplex Plunger Pump—What is the capacity in gallons pumped per minute of a single-acting triplex plunger pump having plungers 5½ in. diameter by 8 in. stroke and making 28 r.p.m.?

M. M. G.

The cross-sectional area of each plunger would be 5½ × 5½ × 0.7854 = 23.758 sq.in., and having three plungers, each with 8-in stroke, the total displacement would be:

$$23.758 \times 8 \times 3 = 570.192 \text{ cu.in. or}$$
$$570.192 \div 231 = 2.468 \text{ gal. per rev. or}$$
$$2.468 \times 28 = 69.1 \text{ gal. per min.}$$

The actual amount of water pumped would be less according to the "slippage," which would depend on the temperature of the water, height of suction lift, size, design and arrangement of suction and discharge valves and piping, and adjustment of the plunger packing. Under ordinary conditions the slippage would amount to about 5 per cent. and the net pumpage would be 95 per cent. of 69.1 or about 65½ gal. per min.

Racing of Electric Elevator—What would cause an electric elevator to race occasionally on its upward trip?

J. B.

If the electrical connections are not making good contact and the shunt field circuit is open, the motor will race, if compound-wound, or if shunt-wound the fuse will blow. A ground in the field coils, combined with a ground on some other part of the system, will also cause high speed. If the car is over counterweighted it may race on the up travel if the series field winding is not cut out of circuit. This is accomplished when the starting resistance is cut out, consequently it may be that the rheostat arm has stuck. Again, the operating mechanism may have drifted back to where it cut off the current from the motor, but not far enough to apply the brake. This would cause the car to race on the up travel without load if the counterweights are heavier than the car. Also, if the controller has been recently overhauled, some of the connections may have been misplaced.

Copper-Ball Pyrometer—How is the temperature of gases escaping from a boiler determined by means of a copper-ball pyrometer?

R. G.

A copper ball of known weight is suspended in the uptake at a point where the temperature is to be taken and after the ball has attained the same temperature as the surrounding gases it is quickly dropped into a vessel containing a known weight and temperature of water. The water is rapidly stirred and its maximum temperature is taken, i.e., when the ball and water have attained the same temperature. The temperature of the copper ball before being cooled would then be given by the formula:

$$x = \frac{W\,(T - t)}{w\,S} + T$$

in which

x = Temperature sought;
W = Weight of the water, in pounds;
w = Weight of the copper ball, in pounds;
t = Initial temperature of the water;
T = Maximum temperature of the water and final temperature of the copper;
S = Specific heat of copper, which may be taken as 0.095.

For example, if the weight of water is 20 lb., the weight of copper ball 12 lb., the initial temperature of the water 52 deg. F. and the maximum temperature of the water and final temperature of the copper is 85 deg. F., then the temperature of the copper ball before being cooled would be

$$\frac{20 \times (85 - 52)}{12 \times 0.095} + 85 = 663.9 \text{ deg. F.}$$

The actual temperature of the waste gases will be somewhat more than the result obtained by use of the formula, on account of corrections for variations in the specific heat of the water and metal for different temperatures, losses of heat by radiation of the metal during transfer from the uptake to the water, and heat lost during the heating of the water and absorbed by the vessel containing it.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

The Efficiency of Heat Engines

A heat engine is an apparatus for converting heat energy into mechanical work. In engines of the internal-combustion class this whole process is carried out within the self-contained machine to which the name "engine" is commonly given. In a steam plant functioning begins at the heating surface of the boiler (where heat is received) and extends to the condenser (where heat is given up), so that here the term "heat engine" covers a good deal more than the steam engine or turbine alone.

The efficiency of any energy converter is the ratio of useful output to total input. There is a class of transformations—typically, those of the electric generator and motor and of machinery transmitting power—in which output is, or may be, nearly equal to input. The difference (decrease) is due to secondary losses, which may be controlled and diminished, but never wholly eliminated. However, it is easy to imagine a perfect electro-dynamo, or a frictionless machine, which shall have no losses and, therefore, unit efficiency. This ideal action, with the apparatus delivering in useful form all the energy that it receives, stands as a limit of performance to which the actual machine approaches more or less closely.

But the heat engine does not tend to approach unit efficiency or complete conversion of heat as its action is improved. Instead, there is a limiting efficiency of lower value, which depends upon the general conditions of operation and is expressed by a fraction ranging in various cases from 0.15 to perhaps 0.65. The typical range for good steam plants, running condensing, is 0.30 to 0.35—this being in terms of heat received by the steam from the fire and, therefore, not including boiler efficiency. In other words, an ideally perfect steam-engine plant, with losses by reason of radiation, cylinder-wall action, or resistance to flow of steam, could convert into work 30 to 35 per cent. of the heat received, and would unavoidably reject in its exhaust the remaining 70 to 65 per cent. The actual plant will do about two-thirds as well as the ideal, converting 20 to 24 per cent.

Having given nothing more than the general law or principle that energy is convertible from one kind to another, one might think that the conversion, for instance, of heat into work could be effected in a number of ways, of which the best or most convenient would be chosen for practical application. Really, however, no such freedom of choice exists with this particular conversion; rather, there is but one general method available, that which depends upon the use of an expansive medium, a vapor or gas. Of course, attempts have been made to find or invent some other way, but these have been altogether fruitless, and the heat engine of common type is the only known device for getting work from heat.

The question now to be considered is, "How is it that the heat engine, even under ideal conditions, cannot have unit efficiency?" The word "how" is used instead of "why," of intention. The latter might imply that the question was one to be solved by some train of abstract reasoning based upon an initial concept of the general nature of energy. On the contrary, there must be study and analysis of the physical processes involved, bringing them to expression in simplest terms and leading to a simple final statement of physical impossibility.

In the manner just indicated let us now consider two typical heat engines, taking the steam plant with piston engine and the gas engine with explosive or Otto cycle as representative examples. Their cycles of operation, briefly described in parallel schedules, are as follows:

1. Taking the charge and bringing it to the state where it begins to receive heat.

Steam plant: For each working cycle of the engine, a certain amount of water under atmospheric pressure and at a temperature not higher than the atmospheric boiling point is put into the boiler by the feed pump, which performs the work necessary to that end.

Gas engine: A cylinderful of mixed air and gas is drawn in and then compressed. In the ideal case the charge would neither receive nor yield up any heat during this operation, so that the compression would begin at atmospheric temperature and would be truly adiabatic.*

2. Imparting heat to the charge.

Steam plant: The water is first raised to the temperature of steam formation and then vaporized, the latter effect requiring by far the larger part of the heat supplied. Room for the very great increase of volume from liquid to vapor is made by the advance of the engine piston, out to cutoff. The work of this expansion is, of course, performed usefully upon the piston.

Gas engine: The charge is ignited and its heat of combustion causes a great rise of temperature and pressure, the volume remaining nearly constant while the piston is moving slowly near dead-center.

3. Expansion without heat supply.

Steam plant: After cutoff, the steam expands behind the advancing piston.

Gas engine: This expansion constitutes the whole of the working stroke.

In both cases the ideal condition for best effect would be to have this expansion take place in a cylinder that was thermally neutral, or that would neither conduct, absorb, nor give up heat. The unavoidable departure from adiabatic action, with real metal cylinders, is one of the chief causes of the gap between ideal and actual performance.

4. Exhaust and removal of unused heat.

Steam plant: Except for a small amount of radiation, the heat not converted goes out in the exhaust steam. Whether taken into the atmosphere directly or into a current of condensing water, it ultimately settles down to the general level of outside temperature.

Gas engine: Heat is taken from the cylinder continually by the jacket water, and the rest of the unconverted heat goes out into the atmosphere in the exhaust gases.

The purpose of the preceding brief review of well

*Adiabatic is a short equivalent for the phrase, "without giving or receiving heat."

known facts is to furnish a reason for, and a practical illustration of, the following general statements:

To get work from heat it must be available at some high temperature, well above that prevailing in the atmosphere and other surrounding bodies.

This heat is applied to some liquid or gaseous medium, causing it to expand and do work.

When at the end of expansion, which is limited by its falling to a pressure below which no useful effect can be got, the medium still contains a large part—commonly much the larger part—of the heat which it has received. Nothing can be done with this heat but to reject it to the atmosphere or surrounding bodies.

All of the work done by the steam or gas in its expansion is not useful output, because the piston must give back some work in expelling the exhaust or compressing the new charge.

These statements are more nearly related to the actual practical engine than to the abstract and, in several respects, imaginary apparatus which is assumed in thermodynamic discussions. They leave some loose ends, but cover the ground well enough. To sum up, the reason why the heat engine cannot attain unit efficiency is that at the end of expansion, when the working medium has performed all the work of which it is capable, it still contains a large portion of the original supply of heat, which has been reduced in temperature and can only be given up or thrown away at this low temperature.

In connection with the performance of any heat engine there are three efficiencies to be considered, which can most clearly be defined in relation to an example. The best test of the Brown-Boveri-Parsons turbine at Newcastle-on-Tyne, which was reported in POWER for Apr. 18, 1911, gave the following data and results:

Load, 6257 kw., on a rating of 6000 kw.; steam pressure, 204 lb. abs.; steam temperature, 560 deg. F., or 176 deg. of superheat; exhaust (condenser) pressure, 0.44 lb. abs., corresponding with a steam temperature of 76 deg.; steam consumption, 11.95 lb. per kw.-hr.

Since one kilowatt-hour is equivalent to 3412 B.t.u., the heat energy converted and delivered at the busbars for each pound of steam is

$$3412 \div 11.95 = 286 \textit{ B.t.u.}$$

The heat of formation of one pound of steam, assuming feed water at the temperature of the exhaust steam, is

$$1299 - 44 = 1255 \textit{ B.t.u.}$$

With ideal Rankine-cycle performance, the output per pound of steam would be 416 B.t.u. converted into work. Then the ideal efficiency is

$$\frac{\textit{Ideal output}}{\textit{Heat input}} = \frac{416}{1255} = 0.332$$

The actual, absolute efficiency is

$$\frac{\textit{Actual output}}{\textit{Heat input}} = \frac{286}{1255} = 0.228$$

And the relative efficiency, the ratio of actual to ideal performance, is either

$$\frac{\textit{Actual efficiency}}{\textit{Ideal efficiency}} = \frac{0.228}{0.332} = 0.687, \text{ or}$$

$$\frac{\textit{Actual output}}{\textit{Ideal output}} = \frac{286}{416} = 0.687$$

This ratio is the real criterion of effectiveness, since it shows how well those losses which are more or less subject to control are kept down. Of course, the 0.228 and 0.687 include the combined mechanical and electrical efficiency of the turbo-generator, which is probably about 0.96. Therefore, the efficiencies in terms of power developed by the steam on the turbine rotor are probably about 0.24 and 0.72.

As Dangerous as Dynamite

A steam boiler with an inoperative safety valve is about as dangerous as a supply of dynamite. Wagons loaded with high explosives may be seen any day passing through the streets of crowded New York. Attention, however, is drawn to the danger by means of large red letters and and a red flag hung conspicuously from the rear of the vehicle. But boilers carrying high steam pressure and having plugged safety valves exist under the sidewalks of this great city without any warning visible to the unsuspecting pedestrian.

This statement may seem sensational, but it is based upon fact.

Just recently an insurance company was asked to insure a boiler carrying a pressure of 30 lb. After examining the boiler the inspector ordered the pressure reduced to 15 lb., but the owner wanted to carry 30 lb., and upon his earnest request the insurance company consented to make a re-examination. When the inspector arrived he found the safety valve blocked, a stick of wood having been wedged between the top of the valve lever and the bottom of the ceiling joist in the building. Needless to say, the insurance was immediately suspended. Insurance on this boiler would not now be accepted even after the pressure had been reduced and the safety valve unlocked.

Fortunately, it is a rare occurrence to find a safety valve that has been purposely blocked to permit the carrying of higher steam pressure. In fact, the writer knows of but one other case, and that was done by a negro fireman who stated that he had to do it to prevent the safety valve from discharging steam.

Safety valves, however, are often blocked unintentionally or by accident. Not long ago a boiler located under a Broadway sidewalk at Forty-first St., after undergoing repairs, was tested by hydrostatic pressure. To apply this pressure it was necessary to block the safety valve. The boiler attendant, unaware that the boiler tester had not removed the block, raised steam on the boiler. The boiler exploded, badly damaged the surrounding property and fatally injured the son of the owner.

In another case the corrugated ceiling over two boilers sagged to such an extent as to come into direct contact with the top of the safety valves. The boilers were located under the sidewalk of a crowded thoroughfare. Fortunately, the danger was discovered by an inspector before explosion occurred.

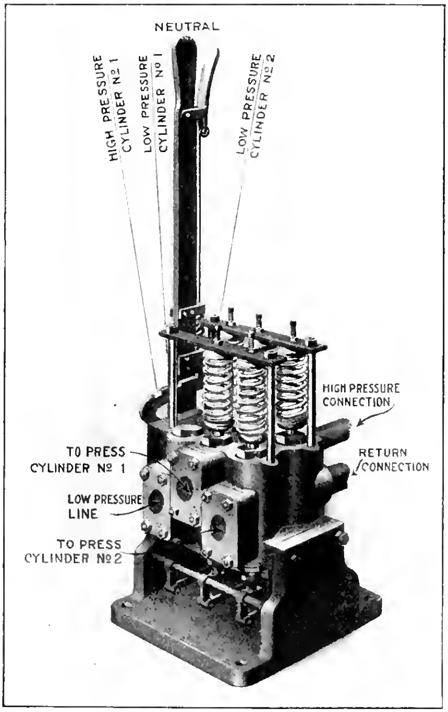
All but one of the instances here cited occurred in New York City within the last two or three months. Considering the vast number of boilers throughout the United States, it is reasonable to suppose that a very considerable number are operated under dangerous conditions.

It is obvious, therefore, that frequent inspections by trained experts are absolutely necessary. There is reason for the movement recently inaugurated in so many states for the adoption of a uniform compulsory boiler-inspection law—a law which will provide for regular inspections, either by state inspectors or by the inspectors of boiler-insuring companies duly authorized to insure boilers in the given state.—*Monthly Bulletin of the Fidelity and Casualty Co., Jan., 1915.*

New Hydraulic Valve

Operators of hydraulic equipment of the double-acting character have experienced difficulty in obtaining proper pressure control with their valve equipment when the ram is forced in both directions by hydraulic pressure.

To meet this demand the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio, has designed the five-way high- and low-pressure double-acting balanced poppet operating valve illustrated herewith.



Five-Way High- and Low-Pressure Double-Acting Balanced Poppet Operating Valve

The low pressure is admitted to the first cylinder, leaving the second cylinder open to the return line. When the low pressure has done its work in the first cylinder, the high pressure is turned on. A check prevents the liquid from the high-pressure line from flowing into the low-pressure line. The valve can then be shifted to the position which applies low pressure to cylinder No. 2 and releases cylinder No. 1. A similar valve is made with another position, which applies high pressure to cylinder No. 2 with No. 1 still open. In most cases the latter position is not necessary, as the work of cylinder No. 2 is done at low pressure only, as in the case of auxiliary return cylinders. On account of the length of the operating lever it is necessary for the operator to stand above the level upon which the valve rests.

The valve has five stems and checks and is suitable for use with pressures up to 5000 lb.

Appearance as an Element in Power-Plant Value

By Edwin D. Dreyfus

Doubtless the mentioning of the fact that the appearance of and the general care accorded a power plant or other operating system possess concrete value will at first seem commonplace. Everyone will contend that he realizes the importance of good order in any working institution. But do the majority of us take sufficiently seriously the slogan of "watchful care and attention" and make the necessary effort to keep our house in the very best order both from an interior and an exterior standpoint? We may neglect the equipment entrusted to our care so long as no accounting is required, but let the occasion arise and we will quickly find means to do vastly more than we had previously attempted. As it is inherent in us to accomplish greater things, why do we not assume the initiative rather than have the doing of these things urged upon us?

A new era has dawned wherein we find ourselves in a condition of strict regulation, either by keen competition or else through municipal, state or federal supervision. The "survival of the fittest" is going to be more pronouncedly the byword in the future, and it is with this in view that the writer attempts to point to instances wherein the orderliness of the plant may represent an indirect monetary value of material consequence.

Regulation is the order of the day—mainly that of public-service corporations, but to an increasing extent of industrial companies doing an interstate business as well—and though there may be other angles by which this is approached, price or rate control is the one of immediate interest. To determine the proper prices for the output of any plant, we must fix upon a reasonable return upon the investment in or the value of the plant. We need not concern ourselves in this article with what this should be as it is governed by the financial risk. However, the fair value is another matter, and should not be a variable quantity, as it is dependent upon the legitimate investment. The book records of the operating company should show this, but it is only recently that records have been kept that exhibit the construction cost separate from other charges.

Consequently, to derive the value as of a certain date, an appraisal must be made in the majority of cases. Herein lies the tangible value of the general appearance of the plant, because some courts and commissions hold that the present value shall be determined by the "reproduction cost new less depreciation" method. Evidently, if the plant gives an impression of neglect, the deterioration and consequent depreciation may appear more exaggerated than they actually are. Whatever diminution in value may result from the inspection (presuming the regulatory body to be guided strictly by the investigator's report) will in all probability represent a permanent loss unless an appeal is made by the company affected.

It is hardly to be disputed that the company's and the employees' interests are interwoven. If the company possesses an efficient management the welfare of the employee is enhanced, and if the employees are individually efficient the company is insured of greater prosperity.

Let us attempt to illustrate the relationship numerically, taking the power plant as an example. Suppose it is to be appraised for price or rate regulation. Assume that the normal rated capacity is 1000 kw. and the cost to install was $100 per kilowatt, or a total of $100,000. Say where the plant was well maintained the condition was found to be 85 per cent. and where indifferent attention obtained the property was considered to be worth 75 per cent. of its original value of $100,000. Accordingly, the less industrious engineer would have lost his employer 10 per cent., or $10,000. Now if the company had been allowed to earn 8 per cent. upon the present value of its property devoted to public interest and to set aside 5 per cent. to cover necessary renewals and replacements, together with 1 per cent. for insurance and taxes, it should receive 14 per cent. after operating expenses have been met. Through the writing down of the 10 per cent. greater depreciation in one case than in the other the company's earnings may have been reduced 14 per cent. of $10,000, or $1400 per year. And this in a larger degree represents the value of the ambitious engineer-in-charge over the one less energetic.

Volumes have been written upon the different methods of arriving theoretically at depreciation. During the early stages of regulation the "life" method principally was in vogue. Now the theoretical method has substantially given way to determining the amount by actual inspection. Upon this development rests the fact that the plant appearance, irrespective of the running condition, becomes of intrinsic value.

By the life, or theoretical, method the depreciation was arrived at by taking the average length of service obtained from machinery and property as was shown by a wide range of experience. Such results had to be predicated upon the performance of equipment both carefully and carelessly maintained, and consequently this method worked an injustice in some cases and disproportionately favored others. Hence, we have come to employ the actual inspection by a competent person in virtually all recent work.

Inspection to determine the reduction in value, like a great many other things in our daily life, is not an exact science, and in this field particularly the psychological influence and mental impression produced may play a considerable part in the results.

To a great many this discussion may seem mere platitude, but the writer has been in many plants where there was apparently no appreciation of the value of appearances. It is not uncommon to find engineers studying indicator cards, analyzing flue gases and carefully observing the general load and operating conditions, but otherwise unmindful of orderliness. The man who not only secures the last fraction of economy and high efficiency but maintains orderly arrangement is going to be the most highly valued. I have known of two engines which were both running satisfactorily, but the older one was the more carefully groomed and was accordingly marked down for far less depreciation.

In enumerating what could be done in a power plant to maintain a good appearance it might be mentioned that in boiler settings all cracks should be calked and the brickwork pointed up; in rotating machinery all side play and any wabbling due to sprung shafts should be eliminated, although having no bad effect upon the operation of the machinery; pumps in the boiler room subject to accumulation of ash and coal dust caked with grease should be kept rubbed down; boiler fronts kept in brightened condition; water- and steam-pipe leaks stopped even where they are of trifling consequence from an economical standpoint; and the tools and all material and supplies arranged in order.

The old adage that "Cleanliness is next to godliness" is thereby a virtue growing in significance. It is of course understood that "surface" conditions alone will not be sufficient, but the internal state of repairs is sometimes more important. However, it is quite clear that outside appearances virtually have a tangible value.

Dead-Man Broke

On Monday, Jan. 4, at about 3 p.m., a peculiar accident occurred at No. 2 pumping plant of the Jamaica Water Supply Co., Jamaica, Long Island, N. Y. The erection of two new smoke-stacks had just been completed, and the riggers were preparing to leave the premises when the guy stub, or dead-man, broke off near the ground, allowing the stacks to fall over. The dead-man was a short length of railroad rail, probably steel, set into the ground. At the point of failure it showed no bend whatever, but simply a short break.

By prompt and wise action on the part of the chief engineer and the riggers, the service was not interrupted and the output was but slightly reduced for a short time only. The rivets were cut at a joint five or six courses from the bottom, and these short stacks set up in their original places, as shown in the illustration. By this means the boilers were operated by forced-draft blowers while the other sections of the stacks were repaired and made ready to replace.

Although there were several men near-by, no one was hurt.

Condition of Stacks Which Fell When Guy Stub or Dead-Man Broke

Boiler Explosions During First Half of 1914

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb	Size	Killed	Injured	Property Loss	Probable Cause
Jan. 1	St. Louis, Mo	Martin-Haloran-Klaus Laundry Co	12 M	Water-tube	125	75 hp.	1	2	$100	Tube ruptured
Jan. 1	Toledo, Ohio	St. Anthony Church and School		Cast iron			0	0		Low water
Jan. 2	Buffalo, N. Y	Erie R R. Loco.		Locomotive			2	0		
Jan. 2	Indianapolis, Ind	Arcadia Dancing Academy					0	0	$500	
Jan. 2	Lower Glenwood Landing, Penn.	Pittsburgh Coal Co			115		0	0	$1000	
Jan. 2	Terre Haute, Ind	T.-H., I. & Eastern Traction Co		Water-tube	160		0	0		Cast-iron header ruptured
Jan 3	Muskogee, Okla	C W Raymond		Cast-iron sectional					$75	
Jan 4	Norwood, N Y	Norwood Elec. Light Plant		Return-tubular	125	150 hp	0	0	$1000	Unknown
Jan 4	Lima, Ohio	Ohio Elect Light Co		Water-tube						Cast-iron header ruptured
Jan. 4	Dawson Springs, Ky	New Century Hotel		Cast-iron heating			0	0		Section cracked
Jan. 5	Denton, Tex	State Normal School		Cast-iron heating						
Jan. 5	Countiss, Ark	Hammonds Lumber Co					1	5		
Jan. 5	Switchback, W Va	Appalachian Paper Co.		Water-tube			0	1		Tube rupture
Jan. 7	Pelham, Ga	Pelham Oil and Fertilizer Co					0	0		
Jan. 7	Independence, Kan.	Carl Leon Hotel		Cast-iron heating	10	Mod. 40-11	0	0		Five sections cracked
Jan. 7	East Liverpool, Ohio	Tri-State Railway & Elec. Co	8:00 p m	Water-tube			0	0		(Two tube failures)
Jan. 7	North Cambridge, Mass	Willowcraft Shop		Cast-iron heating	15		0	0	Rep by mak'r	Defect in casting
Jan. 8	Fisher, Ill.	Earl Campbells Farm	8:00 a m.	Locomotive type	140	15 hp	0	2	$200	Heads of staybolts corroded off
Jan. 8	Bridgeport, Ill	Ohio Oil Co.	8:00 a.m				3	4	$2500	
Jan. 9	Lowell, Mass	J. N. Adam's Dept. Store					0	0		Blow-off failed
Jan. 9	Lowell, Mass	Prescott Mills					0	0		
Jan. 10	Shaverstown, N Y	Bartlett Bros. Sawmill	9:30 a.m.	Cornish	100	25 hp	2	0	$300	Unknown
Jan. 10	New York City (Astoria)	Malchay & Gibbons, Contractors	12 M	Upright-tubular			0	16		
Jan. 10	Terre Haute, Ind	T.-H., I. & Eastern Traction Co		Water-tube type	160		0	0		Tube rupture
Jan. 11	Cadillac, Mich	Commer-Diggins Mill					0	2		Low water
Jan. 12	East Lebanon, Penn	Leb. Val. Iron & Stl. Co					0	5		
Jan 12	Kansas City, Mo.	Moore Hotel		Cast-iron heating			0	0		
Jan. 12	Waukegan, Ill.	American Steel Wire Co.		Water-tube			0	0		Cast-iron headers ruptured
Jan. 12	Bridgeport, Ill.	Standard Oil Co. Oil Lease	9:00 a.m	Locomotive type	120	25 hp	3	4	$500	Low water, starting injector
Jan. 12	Albany, Ga.	Drake & Thompson Sawmill	7:00 a.m	Return-tubular	100	100 hp	1	2	$3000	Valve closed between boiler and safety valve
Jan. 12	Nowata, Okla.	C. Newbert's Well-Driller	8:00 p m	Locomotive type	120	abt. 30 hp.	0	2	Boiler only	Low water
Jan. 12	Columbia, S. C.	G. A. Guignard's Brickyard		Locomotive			0	1		Crown sheet failed
Jan. 13	Rochester, N. Y	31 Concord St.					0	0		
Jan. 13	New York Cit	Ansonia Apartment Hotel	1:00 a m				0	1		Valve burst
Jan. 13	Flat Rock, Ill	Ohio Oil Co.	11:00 a.m.				0	1		
Jan. 13	Shirley, Ark.	Smile Lumber Mills	3:00 p m				2	0		Cold water admitted to empty boiler
Jan. 13	Braddock, Penn.	American Steel & Wire Co		Water-tube			0	0		Cast-iron mud drum failed
Jan. 13	Roxbury, Mass.	Apt. No. 6 Humboldt Ave		Cast-iron heating	15	9 sections	0	0	Repl'ing sec.	Section cracked
Jan. 13	Lima, Ohio	Ohio Elect. Railway Co.		Water-tube			0	0		Four cast-iron headers failed
Jan. 13	Lawrence Co., Ill.	George Gray Farm	11:00 p.m.		100	25 hp.	0	1		Low water
Jan. 14	Portchester, N. Y.	119 Horton Ave.					0	0		
Jan. 14	Philadelphia, Penn.	J. Block					0	3		
Jan. 14	Red Bank, N. J	Santangelo's Bottling Wks.					0	0		
Jan. 14	Jersey City, N. J.	619 Summit Ave.					0	0		
Jan. 14	Jersey City, N. J.	27 Palisade Ave.					0	0		
Jan. 14	Philadelphia, Penn.	F. M. Worstell					0	0		
Jan. 14	Philadelphia, Penn.	29 Noble Street					0	1		
Jan. 14	Wellsburg, W. Va.	Gas Plant					0	Several		
Jan. 14	Coshocton, Ohio	Coshocton Light & Heat Co.	10:00 a.m.	Water-tube	140	150 hp.	0	1	Tube	Tube rupture
Jan. 14	North Adams, Mass.	J. Alpert		Water front of stove			2	0		Frozen pipe connection
Jan. 14	Jersey City, N. J.	Gotthoff's Store		Kitchen boiler			0	3	$1000	Service pipe frozen
Jan. 14	Huntington, Penn.	Fred Etnier's Home		Cast-iron heating			0	0	$3500	
Jan. 14	Plainfield, N J.	A. Hirsch's Home		Cast-iron heating			0	0		
Jan. 15	Butte, Mont.	Pittsmont Mine					0	0		
Jan. 15	Boston, Mass.	Apt. House 98 to 102 Gainsboro St.		Cast-iron heating			0	0		
Jan. 15	Holyoke, Mass.	Garage, E. H. Friedrich					0	1		
Jan. 15	Beaverton, Ala.	Jim Black's Sawmill	8:00 a.m.	Return-tubular	100	20 hp.	3	0	$1000	Low water and water admitted
Jan. 16	Long Island City, N. Y.	J. F. Blanchard		Return-tubular	125		0	0	$100	
Jan. 16	Littleton, N. H.	Saranac Glove Co.		Return-tubular	70	100 hp.	0	0		Crack in sheet. No explosion
Jan. 17	Federalsburgh, Del.	Long Bro's & Co. Store	3:00 p m.	Cast-iron heating	5	40 hp.	0	0		Low water
Jan. 17	Point Pleasant, W. Va.	Grist Mill	2:00 p m.	Locomotive type	85	60 bp.	0	2	$460	Pressure gage out of order
Jan. 17	Lancaster, Penn.	Lefevre's Greenhouse					0	0		
Jan. 18	Galena, Mo.	Campbell Bros. Mine	12:00 p.m.				0	0		
Jan. 18	Mt. Pleasant, Ia.	State Hospital for Insane		Water-tube			0	0		Tube ruptured

BOILER EXPLOSIONS DURING FIRST HALF OF 1914—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Jan. 19	Haverhill, Mass.	W. & V. O. Kimball Co.					0	0	Repairs	Leak only, no explosion
Jan. 20	Lynn, Mass.	J. B. Blood & Co. (Grocery House)		Cast-iron sectional			0	0	Repl'ing sec.	Seven sections ruptured. Low water
Jan. 20	Ft. Wayne, Ind.	Ft. Wayne Bldrs. Supply Co.			90		0	0	$25.00	
Jan. 21	Feebansville, Ill.	St. Mary's School for Boys					0	0		
Jan. 21	Warren, Ill.	High School	9:15 a.m.	Cast-iron heating	3	S. 36-8	0	0	$100	Four sections cracked
Jan. 21	Ottawa, Ont., Can.	Horwick Hall	8:05 a.m.	Return-tubular	20-40	60 in. x 14 ft.	3	6	$100,000	Safety valve inoperative
Jan. 22	Des Moines, Ia.	B. F. Kauffman & Office Bldg.					0	0		
Jan. 22	Shelby, Ala.	Shelby Iron Co.					2	1	$2000	
Jan. 22	El Paso, Tex.	El Paso & Southwestern Railway					1	3		
Jan. 22	Elyria, Ohio	Clev., Southwestern & Col. Trac Co.		Water-tube	150	425 hp.	0	1	Tube	Tube pulled out
Jan. 23	Kewjawhatchee, Ala.	Shelby Iron Wks.					1	0		
Jan. 23	Washington, D. C.	The Chapin-Sacks Mfg. Co.	11:40 p.m.	Water-tube	140	250 hp.	0	1	$300	Tube ruptured. Defective tube
Jan. 26	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	150 hp.	0	0		Cast-iron header failed
Jan. 26	Gloversville, N. Y	101 Water St.					0	0		
Jan. 26	Kansas City, Mo.	Charlotte Apartments		Hot water			0	0	$150	Defective connections
Jan. 27	Pittsburgh, Penn.	National Tube Co.		Water-tube			0	4		Tube ruptured
Jan. 28	Omaha, Neb.	Y. M. C. A.	11:00 a.m.	Return-tubular	100	125 hp.	0	0	$100	Mud and scale
Jan. 30	St. Augustine, Fla.	Sarasota Ice & Elect. Co.					0	0		
Jan. 31	Lovell, Wyo.	Byron Oil Well		Portable	100		0	0	$1000	Crown sheet failure. Stay bolts all stripped
Jan. 31	Chicago, Ill	Union Special Machine Co.					1	0		Flues failed
Feb. 2	Miami, Fla.	Johnson & Co. (Dredgeboat)					0	0		Crown sheet failed
Feb. 2	Bakersfield, Calif.	Southern Pacific Locomotive	3:20 p.m.	Locomotive (Mallet)			2	0		Unknown
Feb. 3	Lowell, Mass.	Owl Amusement Co.'s Theater		Cast-iron sectional			0	0		Two sections ruptured
Feb. 3	Utica, N. Y.	Hotel Utica Garage	6:00 a.m.	Blow-off Tank			1	1		Outlet closed
Feb. 4	Shelby, Ala.	Iron Works Pumping Station					1	1		
Feb. 5	Urban, Ky.	Sawmill	3:00 p.m.	Locomotive type	110	45 hp.	6	4	$1000	Low water, cold water put in
Feb. 5	Howenstine (near) Canton, Ohio	Traction Engine			150		1	3		Overpressure
Feb. 6	Waukegan, Ill.	Am. Steel & Wire Co.		Water-tube			0	0		Tube ruptured
Feb. 6	Hiawatha, Kan.	Brier Shadel Mercantile Co	•	Cast-iron sectional	30' head		0	0	$50	Scale, hot water used from system
Feb. 6	Indianapolis, Ind.	Indianapolis Light & Heat Co.		Water-tube	200	612 hp.	0	0		Water hammer, strained rivets in bead
Feb. 7	St. Louis, Mo.	Wabash Locomotive	4:00 p.m.				0	3	$750 to bldgs	Crown sheet failed
Feb. 8	Canal Dover, Ohio	Reeves Mfg. Co. Tin Mill		Water-tube			0	0		Tube ruptured
Feb. 9	St. Louis, Mo.	Union E. L. & P. Co.		Water-tube	175		0	0	$140	
Feb. 9	Ft. Wayne, Ind.	Tompkinson Plumbing Shop					0	1		
Feb. 9	Coronado, Calif	Coronado Beach Co.		Water-tube			0	2		Tube ruptured
Feb. 11	Dubuque, Ia.	Wm. Lawther Co.'s Plant	2:30 a.m	Return-tubular	70	52"x16'	0	0	$100	Blow-off failure
Feb. 11	Bakersfield, Calif.	Bankline Oil Co. (Pumping Plant)					0	0		
Feb. 12	McComb, Ohio	Smith Block					0	1		
Feb. 12	Asbury Park, N. J.	North Asbury Fire Co. Station		Heating			0	0		
Feb. 12	Arlington, Mass.	Arlington Five Cent Savings Bank		Cast-iron sectional	8		0	0	Repl'e'g sect.	Low water Section cracked
Feb. 12	Wellsley, Mass.	Dana Hall School		Cast-iron heating	7	12 sections	0	0	$500	One section and one manifold failed
Feb. 12	Mishawaka, Ind	Dodge Mfg. Co.		Water-tube	125	150 hp.	0	0		Cast-iron header ruptured
Feb. 12	Cleveland, O	J. M. Gasser & Co. (Greenhouses)		Fire-tube	60	75 hp.	0	0		Blister in firebox caused by scale. No explosion
Feb. 12	North Bergen, N. J.	No 5 School Building					0	3		
Feb. 12	Ravana, N. Y.	Grammar School	10:00 a.m.	Cast-iron heating		3500' cap	0	0		Old boiler worn out
Feb. 12	Burlington, N. J.	Street Car Heater					0	4		
Feb. 16	Cedar Rapids, Ia.	J. A. Moeller's Creamery					0	1		
Feb. 16	Cincinnati, Ohio	Cincinnati Coffin Co.					0	1		Blow-off failed
Feb. 16	Chicago, Ill.	P. & S. R.R. Demonstration Car					0	1		
Feb. 16	Detroit, Mich.	Fredk. Sterns & Co					0	1		Blow-off failed
Feb. 16	Knob Noster, Mo.	Acme Milling Co.	6:15 a.m.	Horizontal-tubular	85	16x51	0	0	$1000	Low water
Feb. 16	Terre Haute, Ind.	T.H.-I. & Eastern Traction Co		Water-tube	160		0	0		Cast-iron header failed
Feb. 16	Elkhart, Ind.	"Little Casino" Restaurant	3:30 a.m.	Cast-iron sectional	70	No. 20	0	1	$300	Unknown
Feb. 16	South Boston, Mass.	Northern Stores & Dock Corp., D St.		Cast-iron sectional	3		0	0	Repl'e'g sect.	Section cracked. Low water or flaw
Feb. 17	Schuylkill, Penn.	Losch Opera House					0	0		
Feb. 18	Lake Charles, La	Hi-Mount Bakery	6:00 a.m.	Vertical	15	2 hp.	0	0	Boiler $20	Sacks piled on safety valve lever
Feb. 18	Pottstown, Penn.	Storb Trappe Rock Co.		Locomotive type			0	0		Crown sheet failed
Feb. 18	Independence, Kan.	Carl Leon Hotel		Cast-iron heating	10	M. 40-11	0	0		Two sections cracked "Negligence"
Feb. 19	Baltimore, Md.	Continental Trust Co.		Water-tube			0	0		Cast-iron header failed
Feb. 19	Kalamazoo, Mich.	King Paper Co.		Water-tube			0	0		Tube failed
Feb. 21	Milwaukee, Wis	Mill. Coke & Gas Co.		Water-tube	150	400 hp.	0	0		Six cast-iron headers failed
Feb. 21	Wheeling, W. Va	Wheeling Steel & Iron Co.		Water-tube	110		0	0	$75	Tube ruptured
Feb. 22	Chicago, Ill.	Swift & Co. (Bldg. 20)		Water-tube			0	0		Tube ruptured
Feb. 22	Winchester, Mass	Residence J. C. Kelley	5:00 a.m.	Water heater	45	16"x5'	0	0		Check valve on supply and no relief
Feb. 22	Far Rockaway, L. I., N. Y.	Residence W. I. Wolfe					0	0	$1000	
Feb. 22	Bellevue, Ohio	Bellevue Light & Power Co	2:30 p.m.	Return-tube	100	100 hp.	2	0		Undue pressure Flaw in belly sheet
Feb. 23	Philadelphia, Penn	Miller Lock Co.		Water-tube			0	0		Tube failure

BOILER EXPLOSIONS DURING FIRST HALF OF 1914 Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb	Size	Killed	Injured	Property Loss	Probable Cause
Feb. 21	Philadelphia, Penn.	Mansbach & Co.					0	0		
Feb. 21	Boston, Mass.	"The Sheffield" Apartment House	11:30 p.m.	Cast-iron sectional	15	12 sections	0	0	Repairs	Low water
Feb. 21	Troy, Ohio	City Pumping Station	3:00 p.m.	Water-tube	150	100 hp	0	0	$80	Cast-iron header failed
Feb. 24	Indianapolis, Ind.	American Hominy Co.		Locomotive boiler			0	2	$3000	
Feb. 24	Peabody, Mass.	National Calfskin Co. (Tannery)					0	0		Four tubes collapsed
Feb. 24	Kansas City, Kan.	Peet Bros. Mfg. Co.		Water-tube			0	1		Tube failure
Feb. 25	Hartford, Conn.	Sisters Holy Ghost Corp.		Cast-iron sectional			0	0		Sections cracked
Feb. 25	New York City, N. Y.	Apartment House, 111 E. 113 St		Cast-iron sectional			0	0		
Feb. 25	Dayton, Ohio	Barney & Smith Car Co.		Water-tube			0	1		Tube ruptured
Feb. 26	New York, N. Y	Apartment House No. 1757 3d Ave.		Hot-water heater			0	3		
Feb. 26	Chicago, Ill	Crane Co.		Water-tube			0	0		Tube ruptured
Feb. 26	St. Joseph, Mo	High School, St. Joseph					0	1		Blow-off failed
Feb. 27	Newburgh, N. Y.	Grace M. E. Church					0	0		
Feb. 27	Indianapolis, Ind.	Chapman Steel Co.	3:00 p.m.	Return-tubular		130 hp.	0	0	Cost patch	Scale caused bag. No explosion
Feb. 27	Kennett, Mo.	Willis & Lasswell's Dredge Boat	9:30 p.m.	Locomotive type	100	60"x11'	0	1	$5000	Low water
Feb. 27	Birmingham, Ala.	Birmingham Infirmary		Cast-iron sectional	10		0	0	$300	Sections cracked
Feb. 27	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	150 hp	0	0	$50	Cast-iron header failed
Feb. 28	Sigourney, Ia	Sigourney Electric Co.	9:30 p m.	Return-tubular	135	200 hp.	0	1		Blow-off failed
Mar. 2	Canton, N. C.	Restaurant	5:00 a.m.	Water back in range	50		0	1		Pipes frozen
Mar. 2	Des Moines, Ia.	St. John's Lutheran Church	11:00 p.m.	Cast-iron heating			0	0	$12,000	Excess pressure
Mar. 2	Baltimore, Md.	Wm. A. Leonard's Book Bindery		Hotwater heater			0	2		
Mar. 2	Rockford, Ohio	Rockford Electric Light Co.	9:00 p m.	Scotch marine	135	8'x13'	0	1	$1400	Furnace collapsed
Mar. 3	Indianapolis, Ind.	Aetna Laundry Co.	9:00 a.m.	Marine type	80	40 hp.	0	0	$400	Unknown
Mar. 3	Stephen, Minn.	Electric Light & Water Works					0	0		
Mar. 3	Howard City, Mich.	Fred Le Barr's Farm	4:00 p.m.	Locomotive type	100	10 hp.	0	2	Boiler only	Old boiler, excessive pressure
Mar. 3	Terre Haute, Ind.	T. H. Ind. & Eastern Traction Co		Water-tube	160		0	0		Cast-iron header failed
Mar. 4	Sharon, Penn.	Carnegie Steel Co., So. Sharon		Water-tube			0	1		Tube failure
Mar. 4	St. Louis, Mo.	5670 Clemens Ave.					0	1		
Mar. 5	Kansas City, Mo.	Irish Cleaning Shop					0	0	$1000	
Mar. 5	Detroit, Mich.	R. H. Cook's Home		Cast-iron heating			0	0	$300	Sections failed
Mar. 6	Terre Haute, Ind.	Indiana Milling Co.					0	0		
Mar. 6	Syracuse, N. Y.	Sanderson Steel Plant					1	0		
Mar. 7	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	15	0	0		Cast-iron header failed
Mar. 7	N. Y. City, N. Y	Carrol Box & Lumber Co., E. 18 St					0	5		Blow-off failed
Mar. 7	St. Louis, Mo.	Bueter Hawkins Specialty Co.					0	1		
Mar. 8	Morganza, Penn.	Training School, Commonwealth Pa.		Cast-iron sectional			0	0		Sections failed
Mar. 8	Wyandotte, Mich.	Michigan Alkali Co.		Water-tube			0	0		Tube failed
Mar. 9	Waynesboro, Penn.	Landis Machine Co.	8:00 a m.	Return-tubular	20	96"x20'	0	0	$40	Low water gage obstructed
Mar. 9	Berwick, Pa.	Chas. Shaffer's Home	11:00 a.m	Cast-iron sectional	3	for 11 rooms	0	0	$75	Unknown
Mar. 10	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	150	0	0		Cast-iron header failed
Mar. 10	Benford, Tex.	Benford Lumber & Mfg. Co.					2	3		
Mar. 10	Burlington, N. J.	Albert Darr's Box Factory					0	2		Attempting repair under pressure
Mar. 12	Wellsville, N. Y.	Griswold Bros. (Fulmer Valley)					0	1		
Mar. 13	New London, Conn	N. Y. N. H. & H. R.R. Locomotive	10:13 p m.	A.L.W. radial stayed			3	0	$100	Low water, crown sheet failed
Mar. 14	Buffalo, N. Y.	Central Casket Mfg. Co.		Cast-iron heating			0	0		Sections failed
Mar. 16	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	150	0	0		Cast-iron header failed
Mar. 16	Wallace, Idaho	City Dye Works	10:00 a.m.				0	0	$1500	
Mar. 16	Kalamazoo, Mich	Wm. Shakespere, Jr., Plant					0	1		
Mar. 17	Madisonville, Ky	Ruby Lumber Co.	7:00 a m.	Return tubular	100	60"x16"	1	2	$100	Blow-off failed
Mar. 17	Troy, Ohio	City Pumping Station	1.30 p.m.	Water-tube		100 hp.	0	0	$200	Two cast-iron headers failed
Mar. 18	Charlotte, N. C.	Central Hotel		Cast-iron heating			0	0		Sections failed
Mar. 18	Brodrick, Penn.	John Antonia, Saloon	2:00 a.m.	Cast-iron heating	20	"126 S"	0	0	$5000	Unknown
Mar. 18	Jackson, Mich.	City Hall Bldg.					0	0		Flues burst
Mar. 18	New Canaan, Conn.	Southern New England Tel. Co.		Cast-iron heating			0	0		Sections failed
Mar. 18	Pen Argyle, Penn.	Penn Bangor State Quarry	2:20 a.m.	Return-tubular	110	125 hp	1	0	$7300	Not known
Mar. 19	Grassland, Ill.	Pumping Station Southern R.R	1:30 p.m.				1	0		
Mar. 19	Tiltonville, Ohio	Prime, Western Smelting Co.	7:00 a.m.	Hoisting engine			3	3		Over pressure
Mar. 20	Lake City, Mich.	F. H. Nye's Sawmill	7:30 a.m.	Locomotive type	120	10 hp.	1	1	$150	Safety valve (above roof) frozen, old boiler
Mar. 21	N. Y. City, N. Y.	Apartment House, E. 42 St.		Cast-iron heating			0	0		Sections failed
Mar. 21	Tolluca, Ill.	C. & A. Locomotive					0	0		
Mar. 21	Clarksburgh, W. Va.	Box Factory	10:00 a.m.	Return tubular	90	150 hp.	1	3		Blow-off pipe failure
Mar. 23	Easton, Penn.	Richter's Store and House					0	0		
Mar. 23	Bowling Green, Ky.	W. T. Smith, Sawmill	4:00 p.m.				0	1	$3000	Flaw in boiler
Mar. 26	Crowley, La.	La. & Western C.H.& S.A. R.R.	2:20 a.m.	Locomotive			0	2	$1500	Low water
Mar. 27	Carnegie, Penn.	Superior Steel Co.		Water-tube			0	1		Tube ruptured
Mar. 28	Medina, N. Y.	Maryland Dredging & Const. Co.		Locomotive type			0	0		Crown sheet failed
Mar. 28	Mishawaka, Ind.	Dodge Mfg. Co.		Water-tube	125	150	0	0		Cast-iron header failed
Mar. 31	Memphis, Tenn.	Memphis Steam Laundry Co.	11:00 a.m.	Water-tube	120	350 hp.	0	0		Cast-iron headers failed; 7 in front and 2 in rear
Mar. 31	Fanwood, N. J.	P. & R. Ry. Locomotive	4:30 a.m.	Locomotive type			0	2		Low water
Apr. 2	Boston, Mass.	"The Sheffield" Apt.		Cast-iron sectional			0	0		Four sections ruptured
Apr. 2	Boston, Mass. (Olive St.).	W. H. Gallison Co.					0	0		
Apr. 2	Boston, Mass., No. 394 Mass. Ave.	"The Sheffield" Apt. (2 same day)	11:30 p.m.	Cast-iron sectional	15	12 section	0	0	$460	Low water, neglect
Apr. 2	Westville, N. S.	Drummond Collieries	9:00 a.m.	Water-Tube	100		7	5		
Apr. 2	Monmouth, Ill.	Monmouth College	3:00 p.m.	Return-tubular	50	60"x16'	0	0	$50	Blow-off failed by sudden closing of valve
Apr 2	Rockwood, Mich.	American Silica Co.		Return-tubular		125 hp	0	1		Blow-off pipe failed

BOILER EXPLOSIONS DURING FIRST HALF OF 1914—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	Injured	Property Loss	Probable Cause
Apr. 3	Seattle, Wash.	Schwarger-Nettleton Mills		Water-tube			0	0		Tube ruptured
Apr. 3	Cedarhurst, L. I.	G. J. Waters (Residence)					0	0	$6000	
Apr. 4	Richmond, Va.	W. J. Parrish's Brickyard					0	0		Oil to boiler caused overheating
Apr. 6	Norfolk, Va.	Torpedo Boat "Aylwin"	4:20 a.m.	White-Forster (naval)	250	4000 hp.	3	0		
Apr. 7	Richmond, Va.	W. J. Parrish's Brickyard					0	0		Oil in boiler caused overheating
Apr. 10	Grand Rapids, Mich.	La Cross Gas & El. Co. Plant		Water-tube			0	0		Tube ruptured
Apr. 10	Pensacola, Leon Co., Fla.	Ed. Manning, owner, Sawmill	2:00 p.m.	Locomotive type	110		1	0		Low water
Apr. 13	Parishville Center, N. Y.	Sawmill	9:00 a.m.	Locomotive type	125	18 hp.	0	1	$50	Old age, mud and overpressure
Apr. 13	Woodward, Ala.	Woodward Iron Co.					0	2		
Apr. 13	Starkville, Miss.	City El. & Water Works		Water-tube			0	0		
Apr. 13	Cannonsburgh, Penn.	West Penn. Oil Co.	10:00 a.m.				0	0		
Apr. 14	Lutherville, Ark.	Read's Sawmill	9:30 a.m.	Locomotive type	70	40 hp.	1	0	$200	Low water
Apr. 15	Omaha, Neb.	Swift & Co.		Water-tube			0	1		Tube ruptured
Apr. 15	South Amboy, N. J.	Tugboat "Arles"					0	2		
Apr. 15	Omaha, Neb.	Burgess-Nash Co.'s Store	10:00 a.m.	Water-tube	135	150 hp.	0	1	$150	Tube ruptured
Apr. 16	Lebanon, Ind.	Lebanon Mfg. Co.					2	0		
Apr. 16	Estabouchie, Miss.	Rush Mill	6:00 p.m.	Return-tubular	100		0	0	$500	Low water
Apr. 16	Cannonsburgh, Penn.	Sawmill, McConnells Farm					0	0		
Apr. 17	Glassport, Penn.	American Axe & Tool Co.	7:00 a.m.	Water-tube		250 hp.	0	0	$100	Tube ruptured; defective tube
Apr. 21	Bangor, Me.	Orono Pulp & Paper Co.		Water-tube			0	0		Tube ruptured
Apr. 21	Brooklyn, N. Y.	Israel Rokeach					0	3		Blow-off failed
Apr. 22	Brooklyn, N. Y.	Hamilton Club		Water-tube			0	1		Tube failed
Apr. 22	Lindale, Ga.	Mass. Mills in Ga.		Water-tube			0	0		Tube ruptured
Apr. 23	Chicago, Ill.	Armour & Co., Glycerine Works		Water-tube			0	0		Two tubes ruptured
Apr. 23	Hartford, Conn.	Boskwick's Sheet Metal Plant		Cast-iron heating			0	0		Two sections ruptured
Apr. 25	Omaha, Neb.	Peoples Ice & Cold S. Co.		Water-tube	125	250 hp.	0	1	$50	Tube ruptured, faulty tube
Apr. 26	Omaha, Neb.	Swift & Co.,		Water-tube			0	0		Tube ruptured
Apr. 29	Allentown, Penn.	City Water-Works					0	0	$600	
May 1	Duluth, Minn.	M., St. P., Sault Ste. Marie Ry. Co.					0	0		Blow-off failed
May 1	Jersey City	Chas. Lehman		Laundry			0	0		
May 1	Pickwick, La.	Pickwick Lumber Co.					2	0		
May 1	Columbia, Miss.	Enterprise Lumber Co. Sawmill					1	4		
May 2	Ada, Okla.	Oklahoma Portland Cement Co.	4:00 a.m.	Water-tube		250 hp.	0	0	$2.50	Tube ruptured
May 4	Arden, near Grafton, W. Va.	B. & O. Locomotive	8:10 a.m.	Locomotive	200		1	1		Low water, crown sheet failed
May 5	Blackville, S. C.	Blackville Lighting Co.					0	1		
May 8	Wilmington, N. C.	Government Str. "Mercur"					0	2		
May 9	New Baltimore, Mich.	Shore Line Railway Power House	5:15 p.m.	Water-tube		300 hp.	2	1		Tubes pulled out of new steel muddrum
May 9	Pittsburg, Kan.	Joplin & Pittsburgh Ry. Co.					0	0		Tube ruptured
May 10	Altoona, Penn.	Standard Ice Co.		Steam pipe			0	1		
May 10	Bradentown, Fla.	Excelsior Ice Co.	11:30 p.m.	Return-tubular		50 hp.	0	0	$64	Scale
May 11	Norfolk, Va.	S.S. "Jefferson," O.D. Line	10:55 p.m.	Scotch marine	165		11	0		Tube sheet
May 11	Franklyn, Penn.	Public School		Cast-iron heating			0	0		Sections failed
May 12	Waterbury, Conn.	Scoville Mfg. Co.		Water-tube			0	0		Tube ruptured
May 13	Lebanon, Penn.	Semet-Solvay Co.		Water-tube			0	0		Tube ruptured
May 13	Renfrew, Penn.	Pittsburgh & Butler Ry. Co.		Water-tube			0	0		Tube ruptured
May 13	Detroit, Mich.	Detroit Copper & Brass Co.	1:15 p.m.	Water-tube	125	94" drum	1	0	Nominal	Loose scale obstructed tube, tube failure
May 13	Canal Dover, Ohio	Hardestry Milling Co.					0	1		Flue burst
May 14	Hoboken, N. J.	Hoboken Paper Mill					0	1		
May 14	Parishville Center, N. Y.	Stone Sawmill					0	0		
May 14	Waterbury, Conn.	Scoville Mfg. Co.		Water-tube			0	0		Tube ruptured
May 15	Security, Md.	Hagerstown & Frederick Ry. Co.	11:00 a.m.	Water-tube		700 hp.	0	0		Tube ruptured
May 18	Madison, Wis.	Hauseman Brewing Co.		Water-tube			0	0		Tube ruptured
May 18	Scranton, Penn.	Undergood Colliery					0	1		Steam pipe burst
May 19	Bradentown, Fla.	Excelsior Ice Co.	12 noon	Return-tubular		50 hp.	0	0	$35	Scale
May 20	Ecorse, Mich.	Worcester Salt Co.					0	0		
May 21	Vinal Haven, Me.	Bodwell Granite Co.					0	0		Furnace failed
May 23	San Francisco, Calif.	150 Erie St.					0	1		
May 24	Waterbury, Conn.	Scoville Mfg. Co.		Water-tube			0	0		Tube ruptured
May 25	Greensboro, N. C.	Yow's Laundry		Range boiler			1	2	$900	Check in supply, safety valve inoperative
May 27	Sault Ste. Marie, Mich.	Dudo Bros. Sand & Mill Co.					0	0		
May 27	Bellows, Vt.	Moore's Paper Mill	7:00 a.m.	Return-tubular	90	6x18'	1	0		Valve on steam pipe burst
May 27	Stearns, Ky.	William's Mill	10:00 a.m.	Portable	120	30 hp.	0	4	Boiler	Low water
May 27	Newark & Harrison, N. J.	Standard Engineering Co., Dredge					1	3		Tube blew out
May 29	Joliet, Ill.	Fredrick Cowan Co.		Water-tube			0	0		Tube ruptured
May 29	Easley, S. C.	Easley Cotton Mills		Water-tube			0	0		Tubes ruptured
May 29	Seekonk, Mass.	H. E. Cushing's Farm	10:00 a.m.	Vertical	80	15 hp.	1	2		Old boiler, not inspected
May 29	Ten Mile Lake, Ore.	Muetzel Sawmill					2	3	$200	Over pressure
May 30	Brooklyn, N. Y.	Foster Pump Works					0	1		
May 30	Brooklyn, N. Y.	984 Franklyn Ave.	11:00 a.m.	Water-tube	75	150 hp.	0	1		Two tubes ruptured
May 30	Carfile, Ark.	Loutre Shingle Co.	5:00 a.m.	Locomotive			0	0	$800	Crown sheet failed
May 30	Oakdale, La.	Bouman Hicks Lumber Co.	2:35 p.m.	Locomotive	145		5	1	$3500	Broken staybolt
June 2	Puerto, Mexico	Cruiser "Salem"		Water-tube			1	2		Tube burst
June 2	Salamanca, N. Y.	Tunnessa Lumber Co., Locomotive		Air tank			1	0		
June 3	Beaverton, Ore.	Cedar Mills Rock Quarry	4:00 p.m.	Locomotive type	95	13 hp.	0	1		Crown sheet failed
June 3	Fibre, Mich.	Dudo Bros. Mill					0	0	$2500	Safety valve failed
June 3	Duvall, near Columbus, Ohio	Locomotive, N. & W. R.R	3:45 a.m.	Locomotive	180		2	0	$20,000	Low water, crown sheet failed
June 5	Crookston, Minn.	Fredricks Bros.' Farm		Locomotive type		20 hp.	1	1	$1000	Over pressure
June 6	Racine, Wis.	A. J. Horlick		Hot-water boiler			0	0		

BOILER EXPLOSIONS DURING FIRST HALF OF 1914—Continued

Date	Place	Plant	Time of Day	Kind of Boiler	Pressure Carried, Lb.	Size	Killed	In-jured	Property Loss	Probable Cause
June 8	Washington, D.C.	Heurich Brewery		Water-tube	150		0	1		Tube failure
June 8	New York, N. Y.	Apt. House No. 137 E. 33d St		Hot-water boiler			0	0		
June 8	Trenton, N. J.	"Twilight", D. R Trans Co					0	0		"Valve blown out"
June 8	Stamford, Conn.	Locomotive	5:30 a.m.	Locomotive			0	2		Steam pipe blew out
June 8	Meridian, Miss	Meridian Light & Railway Co	6.45 a.m.	Water-tube	150	250 hp.	1	2	$35,000	"Breathing" of the drum head
June 9	Leonard, Tex.	Leonard Light & Ice Co					0	0		
June 10	Monongahela, Penn.	Diamond Coal Co. (Pump Boat)	1:30 a.m.				0	1		
June 11	Davenport, Iowa	Crescent Macaroni & Cracker Co.	6.30 a m.	Return-tubular	110	60"x18	0	0		Low water
June 12	Philadelphia, Penn	Bonfig Bakery					0	1		
June 12	Toronto, Ont	Bowes Produce Co.					0	3		Pipe bursted
June 13	Battle Creek, Mich.	Michigan Carton Co.		Water-tube			0	0		Tube ruptured
June 13	Moline, Ill	Deere Harvester Co.	8:00 p.m.	Water heater		1000 b.hp.	0	1		Back pressure valve stuck
June 13	Richmond, Va.	Millhiser Bag Co.		Return-tubular		60 hp.	0	0	$125	Weak seam indicated; no explosion
June 13	Franklyn, Ga.	J. P. Pyles Farm	10:00 a.m.	Locomotive type	100	15 hp.	4	5	$200	Low water, old boiler
June 15	Franklin, N. H	Ideal Hotel		Hot-water heater			0	0		
June 15	Anderson, Ga.	Tyns' Soda Water Stand					1	1		Charging tank burst
June 17	Oakland, Calif	Piedmont Baths					2	1		
June 20	Milledgeville, Ga.	Milledgeville Ice Co.					0	4		
June 21	Charleston, S. C	Charleston Cons. Ry. & Lt. Co.		Water-tube			0	0		Tube ruptured
June 22	Jennings Gap, Va.	Geo. Shull's Home					0	1		
June 22	Laird, Kan.	C. W. Smith Elect. & Ice. Co.					0	0		Blow-off failed
June 22	Oscoda, Mich.	Portable Sawmill					1	0		
June 22	Bosler, Wyo.	Portable Sawmill					1	0		
June 22	Toledo, Ohio	St. Michaels Church		Cast-iron sectional			0	0		Section cracked
June 22	Arthur (Roanoke) Va.	Norfolk & Western Locomotive	6:15 p.m.	Locomotive	200	$8000	2	0		Low water, crown sheet failed
June 23	Peekskill, N. Y.	Peekskill Hat Mfg. Co.					0	0		
June 23	Littleton, Ill.	Feed Mill	1:00 p.m.	Locomotive type		12 hp.	1	1	$100	Low water
June 24	Williamsport, Penn.	J. C. Decker Novelty Works					0	2		
June 25	Evansville, Ind.	Brown Dredging Co.					0	1		
June 25	Oshawa, Can.	J. W. McCutcheon (King St.)	9:00 a.m.	Portable well drill	80	20 hp.	1	1	$1000	Corrosion at bottom of fire-box.
June 26	Fall River, Mass.	I. L. Prew's Machine Shop					0	0		Blow-off failed
June 26	Chicago, Ill.	Desplaines Safety Deposit Co.		Water-tube			0	1		Tube ruptured
June 26	North Bend, Ore.	Muetzel Sawmill	11:00 a.m.				2	3	$1000	Low water
June 27	Chicago, Ill	A. J. Johnson & Sons Furniture Co.					0	1		Blow-off failed
June 27	Mattoon, Ill.	London Packing Co.		Water-tube			1	0		Tube ruptured
June 29	Philadelphia, Penn.	Standard Roller Bearing	7:30 p.m.	Return-tubular		150 hp	0	1	$1 00	Blow-off failed

Water-Power Legislation

In the deadlock between the President and the Senate over patronage, waterpower legislation at this session of Congress seems likely to be lost in the shuffle. States-right senators, like Smoot of Utah, Borah of Idaho and Clarke of Wyoming, backed by big water-power interests, are understood to be preparing to talk to death the Ferris bill, which has passed the House, providing for the leasing of power sites in the public domain, while the conservationists have declared war on the Shields bill, reported to the Senate as a substitute for the Adamson general dam bill which passed the House last year. The Shields bill is denounced by Gifford Pinchot, president of the National Conservation Association, as "the bill of the water-power monopolists."

The Adamson bill, which had the indorsement of President Wilson, provided for the granting of permits for dams and power plants on navigable streams for periods of not more than fifty years, with reversion of the property to the Government at the end of that period. The Shields bill, while it purports to do this same thing, leaves the way open to endless litigation for determining the fair value of the property at the end of the franchise term, so that it is declared by conservationists that it would be practically impossible for the Government to ever take over the property. Although the only grant to be made by the Government is for the right to build a dam and works adjacent to a navigable stream, the language of the Shields bill would require the United States to take over the entire lighting plant of a city, if it were operated in connection with such power plant, in order to recapture the water power in the stream. The Shields bill also gives to the water-power interests the right to condemn land, either public or private, for their own uses, and would require the Government, on taking over the plant, to pay the increased value of land so taken.

These features of the bill, which are not the only ones to which the conservationists object, are in direct opposition to the policies declared for by Secretary Lane, of the Interior Department, and at odds with the principles set forth in the Ferris bill for the granting of franchises for power sites on public lands.

Of the Shields bill, Mr. Pinchot says in his statement:

There has been no clearer attempt to defeat the conservation policy since water power first became a great National problem. It is a direct reversal of the wise and fair provisions contained in the Adamson bill as it passed the House. President Roosevelt vetoed the James River bill in 1909, President Taft vetoed the Coosa River Dam bill in 1911, because they did not provide for proper payment to the public for value received from the power companies. The House of Representatives by an overwhelming vote adopted the Sherley amendment providing for such payment. The Shields bill proposes to give these rights away. It is a surrender to the special interests, and its passage would be a public calamity.

Recent Court Decisions

Digested by A. L. H. STREET

Remedy for Breach of Power Contract—According to a decision lately handed down by the Georgia Supreme Court, an electric-power company which has an unexpired exclusive contract to furnish a consumer with all electricity used by him for power purposes cannot maintain a suit to enjoin breach of the contract through the consumer's refusal to receive further service, where it appears that the company has an adequate remedy by suing for damages for such breach. (Macon Ry. & Light Co. vs. Palace Amusement Co., 83 "Southeastern Reporter," 105.)

Power as Basis of Mechanic's Lien—The Minnesota Supreme Court has just been called upon to determine the interesting question whether one who furnishes fuel and lubricating oils for the production of power in operating excavating machinery in constructing a building foundation is entitled to a lien against the real estate to secure payment for the fuel and oils on the theory of having contributed toward the improvement of the land. (Johnson vs. Starret, 149 "Northwestern Reporter," 6.) In answering this question in the affirmative, the court said: "Had the excavation and removal of the earth been done by manual labor, the right to a lien therefor would be undoubted, and we cannot differentiate such a case from one where the same result is reached by other and modern methods. The value of the defendant's property was thereby enhanced, and it can make no difference that this was accomplished by the use of power obtained from materials furnished by the lien claimants instead of by common labor."

Thermodynamics of the Marine Oil Engine*

By John F. Wentworth

SYNOPSIS—This paper is intended to present certain experimental data obtained by the writer as well as to reintroduce certain old and well established facts in a new garb, in order that the oil engine may be looked at from a new viewpoint.

The marine plant must be capable of running at full load with maximum power or of running at partial load with maximum efficiency, and most essential at times is the ability to run at extremely slow speeds. Moreover, to meet all conditions and take its place as a perfect prime mover at sea the marine oil engine must be capable of being built in large single units, which means that extreme pressures must be avoided. Therefore, an attempt will be made to show:

First, that if possible the extreme high pressure of compression must be reduced.

Second, that to give the greatest possible efficiency under all conditions the proportions of air to fuel must be kept constant regardless of load.

Third, that to get extreme or emergency slow speed the injection of the fuel and the ratio of air to fuel should be varied contrary to the condition for maximum efficiency.

Fourth, that the percentage of the stroke during which the fuel valve is held open should be under the control of the operator in order that injection air losses may be reduced.

Fifth, that by reducing the compression and at the same time hastening the fuel injection the advantage of the high compression is not materially impaired.

Sixth, that by reducing the compression it is possible to obtain substantially the same power with the same theoretical efficiency, but with an increased mechanical efficiency.

Seventh, that by increasing the temperature of the injection air a saving of practically 10 per cent. of the fuel now used may be effected without danger to the plant.

To understand best the effect of the high-pressure of compression and its relation to the cycle, temperature-volume diagrams of the oil engine and of other types will be considered. Fig. 1 shows two typical Diesel diagrams copied from catalogs of 1898 and 1913. The end of the expansion stroke corresponds with 100 per cent. volume and the beginning with the clearance of the engine, making it possible to read pressures and also percentage volume. Assuming that the compression is begun with air at 14.7 lb. and 60 deg. F., the specific volume will be 13.09, and the specific volume at any other point will be 13.09 times the percentage volume. Thus, from the formula $PV = RT$, the temperature of the charge can be figured with a fair degree of accuracy. The constant R for air is 53.22 in English units. By plotting the two indicator diagrams and figuring a certain number of points the temperature-volume diagrams were drawn in. It will be noted first that the temperature rises almost vertically during injection. This shows, comparing the 1898 and the 1913 diagrams, that the trend of Diesel engine practice approaches the conditions of the gas engine.

If the Diesel engine can start with a compression of 500 lb., the charge igniting at a temperature around 920 deg. F., then after it has been running awhile the temperature at the end of compression must be around 1450 deg. F. If this be so, the charge will ignite at any time after the pressure has exceeded 120 lb., provided the engine has run long enough to become normally warm.

This is demonstrated by the diagrams shown in Fig. 2, which were taken from the writer's experimental engine, although it was not possible to vary the amount of air compressed per stroke as much as desired. Also, the timing of the fuel valve caused slight trouble. Hence, the fuel valve was arranged so that the timing of the injection could be changed, and these diagrams are the result. So far as the writer knows, this is the first instance in which a timing arrangement has been used on the fuel valve. The ignition of the fuel was obtained under conditions which were possible only in an engine which had been run long enough to get warmed up, and it seems a fair assumption that, if the fuel ignited as shown, it would have ignited if the clearance had been so increased that these low pressures were obtained at the end of compression. The fuel is shown igniting at from 70 lb. up to full compression pressure. Diagram No. 6, where the ignition was at 130 lb., makes it apparent that much energy is lost by radiation during the time of high pressure and high temperature. This loss at the end of compression should be somewhat reduced in the low-pressure type, for although the cylinder volume at the end of compression might be doubled, the radiating surface would be only slightly increased.

Next consider the proposition that the ratio of air to fuel be kept constant. This has been done on the best gas engines as a means of governing, but it has not been done on the Diesel, because apparently the full amount of air must be compressed per stroke in order that the ignition temperature may be obtained. In the Mar. 11, 1913, issue of "Power" the writer brought this out, proposing that if only two-thirds of the fuel were used, only two-thirds of the regular amount of air should be compressed. Moreover, if the friction loss is a function of the unit pressure on the piston, then the friction of the Diesel at two-thirds load would be 50 per cent. greater than in the proposed form of governing. This can be stated in another way; namely, the friction is not a percentage of the net load, but is a percentage of the work done in the cylinder, regardless of whether the effect is plus or minus on the brake.

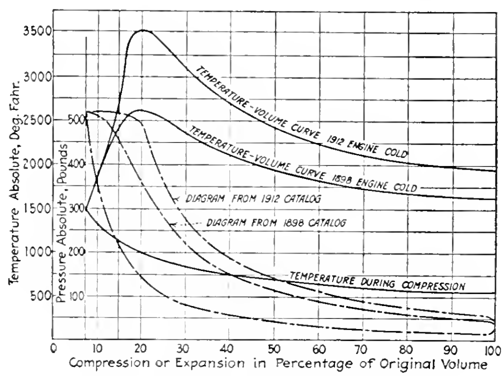


Fig. 1. Temperature-Volume Curves

Fig. 3 is a set of curves constructed from tests made by Professor Denton in 1898 on a small Diesel engine. Improvements have been made in the engine, but the cycle is unchanged, so that results obtained in these early tests are at least indicative of what goes on in the present engines. This diagram shows that the friction is practically constant at all loads and would seem to bear out the contention that the friction is toll taken out of both the compression and the working strokes. With the compression pressure constant the sum of the compression work and expansion work would vary but little for a wide variation in the net work done in the cylinder. However, the sum of the compression and the expansion strokes would vary greatly if the compression pressure was decreased.

Air is compressed and then expanded. The air in itself does nothing. All the work put into compression will be given up in expansion except the losses. If the quantity used per stroke is reduced, the losses per stroke will be diminished by this same amount. Unnecessary compression of air is an extravagance, therefore, for it is needless to compress more than is required for the proper combustion of the fuel.

Next, consider the problem of extremely slow speed. In order to reduce to a very slow speed care must be taken to obtain a maximum temperature at the end of the compression stroke. Diagram No. 6, Fig. 2, shows the effect of cooling

*Excerpts from a paper read at the recent meeting of the Society of Naval Architects and Marine Engineers, at New York.

at the end of compression. For moderate speeds with a falling horsepower the amount of air compressed per stroke can be varied. Under present conditions there is a limit to the speed of the oil engine, at which limit the ignition will be uncertain. To go beyond this in the present engines the air should be heated before it enters the cylinder and the temperature of the jacket water should be raised. It might even be wise in an emergency to cut out the circulating water entirely.

Need for this slow speed was painfully evident when the Diesel-engined ship "Christian X" fell in with a disabled ship in midocean. It was stated at the time that tow lines were repeatedly passed to the disabled ship only to part. Presumably the best that could be done would have been to keep starting and stopping the engines in the hope of gradually accelerating the tow to the point where the line would stand the lowest possible speed of the engine.

A steam vessel under the same conditions would have run her engine very slowly, just enough to give steerage way, until she had taken up the slack of the tow line, and then would have increased the revolutions gradually until the desired speed was obtained. This is manifestly impossible in the present oil engine. In the plant proposed at the end of this paper the motive power would be steam and the engine would start at a few turns per minute with steam from the economizer boilers.

At this point it may not be out of place to call attention to the fact that the cylinders of a Diesel engine should be kept as hot as possible, up to the point of encountering lubricating troubles. This is true whether extremely slow speed or maximum efficiency is required.

Passing to a discussion of the advantages of fuel valve control as to timing, etc., in the present oil engine the duration of the fuel injection does not take into account the amount of fuel to be fed nor the speed. If an engine be slowed down to half speed, considerably less fuel will be used than when running at full speed. Notwithstanding this, the fuel valve is open for the same length of time. This results in a waste of injection air, the thermodynamics of which will be taken up later. If the fuel be injected early in the stroke, a rise in pressure can be obtained which will increase the efficiency. If the fuel be fed into the cylinder a considerable time after the end of the compression stroke, it is possible to produce the same result that is obtained in the explosion engine by retarding the spark. Thus, it seems to be highly desirable to be able to control at will both the timing of the injection and the duration of the fuel feed.

The method of compensating the theoretical loss encountered in reducing the compression pressure next calls for consideration.

If the compression pressure is reduced, the fuel injection can be hastened and combustion completed earlier in the stroke. If high compression is used, then the fuel must be slowly injected, as is now done in the Diesel engine in order that extreme pressure may be avoided. If the fuel be injected rapidly and timed for the end of high compression, results are to be expected similar to those shown in diagram No. 8, Fig. 2.

High compression means small clearance and a relatively large number of expansions, which is desirable, but the full effect is lost through the slow fuel injection. Why this is so is shown in Fig. 4. Assume the indicator diagram to be divided into four similar ones by means of the adiabatic lines shown. Each may be considered separately. In the case of D the average clearance is 16.1 per cent. of the whole cylinder contents, hence it has only 6.2 expansions. Diagram A, on the other hand, has 11.34 expansions. If the fuel be injected rapidly into a cylinder whose clearance gives a compression pressure of 275 lb., then the number of expansions will be 8, or the same as the average of this Diesel diagram.

Attention will now be directed to some of the benefits to be derived from reduced compression. In the engineering press the idea of reducing the compression pressure and at the same time making up for this lower compression temperature by means of a higher temperature of the incoming air has been opposed, the objection being that the volumetric efficiency would be decreased; in other words, the power of the cylinder would be reduced, making the engine more bulky. The original idea was to save fuel by a process similar to compounding; that is, when only a partial load was called for, a partial cylinderful of air would be compressed. If this were done by closing the admission valve at the middle of the suction stroke, a vacuum would be formed in the cylinder during the rest of the stroke which would be maintained during the first half of the compression stroke. In this case volumetric efficiency will not suffer, whereas in the present method of governing the engine at partial loads the efficiency is handicapped by the presence of an unnecessary excess of air.

The economy possible in the injection air is the last point for discussion pertaining to the present type of engine.

From the best information available the injection air compressor must develop about 10 per cent. of the brake horsepower of the main engine. Of this 10 per cent., what care has been used to maintain an economical cycle? The air is compressed in two or more stages to 1000 lb., and then cooled to the original temperature or lower. The total energy in the air after it has been compressed to 1000 lb. and cooled to its original temperature is exactly what it was in the beginning. All that the work of compression has done is to make a part of this original energy available. Our natural conception of the energy of compressed air would lead to the consideration that the energy depended upon the pressure of the air; as a matter of fact, the determining factor is not pressure, but temperature. There are several simple proofs for this statement. One is: "Isoenergic lines are lines representing changes during which the intrinsic energy remains constant. It will be seen later that the isoenergic and isothermal lines for a gas are the same" (Peabody). When the air

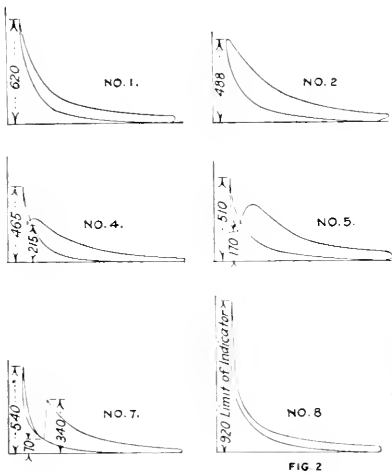


FIG. 2. DIAGRAMS TAKEN ON EXPERIMENTAL ENGINE

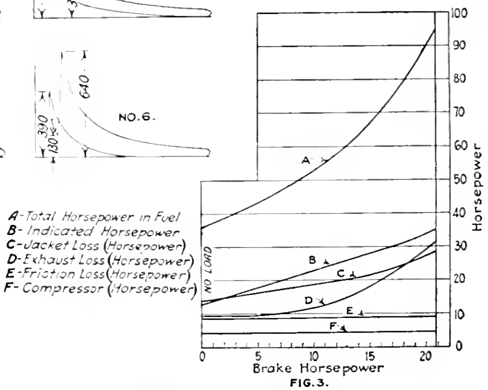


FIG. 3. VARIATION OF LOSSES WITH DIFFERENT LOADS

is cooled to the original temperature after having been compressed, it is brought back to the isothermal from which compression started.

This contention can be proved mathematically. The formula for work of expansion to the absolute zero of temperature and pressure is

$$W = PV \div (k - 1)$$

This formula considers a fixed quantity of air—that is, a certain weight. In the formula $PV = RT$, considering the same weight of air, P and V will be the same as in the formula for work. By substitution, the formula for work can be rewritten $W = RT \div (k - 1)$, where R and k are constants, and the only variable in the formula is T, the absolute temperature. This new formula will give the work of expansion for one pound of gas.

The above consideration of the injection air is simply to bring home the fact that a waste is being made of one-half of the available energy of the compressed air when this air is cooled to room temperature in place of being used at about 580 deg. F. If the injection air is used at this temperature, just one-half of the fuel to run the air compressor will be saved, and there will be no difference in the operation of the engine. Before this can be wisely done, however, there is need for redesigning of the fuel valve. It is the writer's opinion that the valve should be simplified even if the pump is complicated.

In regard to the danger in using air of this temperature there is this to say: Any explosion in the injection line will come from a quick opening of the air valve. If there is a pocket in the line where oil can settle and the air valve is suddenly opened with no pressure in the line, the body of oil will be dislodged from its pocket and shoved along ahead of the incoming high-pressure air, compressing the low-pressure

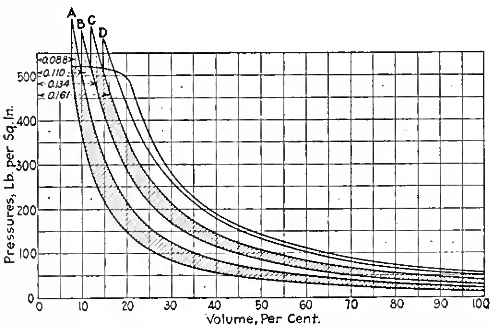


FIG. 4. SHOWING EFFECT OF SLOW FUEL INJECTION

air. If this action in the injection line takes place quickly, the body of oil will take the place of a piston and the action in the injection line will be the same as in the cylinder during the compression stroke. A temperature of ignition will be reached in the injection line regardless of the temperature of the injection air. In fact explosion is caused not by the injection air, but by the contents of the air line when the high-pressure air is turned on. It is possible to safeguard this type of engine from explosion in the injection line by a little care in the design of the piping arrangement, etc., and the exercise of due caution in operation.

The present instructions for the operation of Diesel engines state that the cooling water from the jacket of the fuel valve should be cold to the hand. The writer feels that the fuel valve can be designed so that it needs no jacket whatever. This may be objected to as an unsupported opinion, but it is based upon years of study along this line of work during which nothing has been found to oppose this idea and everything points to its possibility.

In closing, the writer's proposed thermo plant will be considered. Briefy stated, the starting medium is steam, generated in a special boiler. Before starting, the steam is admitted to the jackets of the engine, warming it to a point where starting steam can be used without excessive condensation. After the engine is running on oil the flow through the jackets is reversed, water from the bottom of the boiler enters the bottom of the jacket, and a mixture of steam and water comes from the top and is returned to the boiler. In this case combustion in the cylinder will not increase the temperature of the jacket water, but will transform it from water to steam at the same temperature. Also, the exhaust gases from the engine will pass around and through this boiler

TEMPERATURES AND PRESSURES CORRESPONDING TO DIFFERENT CRANK POSITIONS, TAKEN FROM TYPICAL DIAGRAMS

Degrees of Crank Angle		Compression												
		180	195	210	225	240	255	270	285	300	315	330	345	360
Diesel engine (cold)	Temp. deg. F.......	60	65	67	84	113	145	212	265	420	635	715	872	920
	Press. lb. gage.....	0	0.3	1.1	2 3	5.3	9.0	17.0	30	57	121	222	410	505
Diesel engine (hot)	Temp. deg. F......	260	266	270	293	333	377	468	543	758	1055	1165	1381	1450
	Press. lb. gage......	0	0.3	1.1	2.3	5.3	9	17	30	57	121	222	410	505
Wentworth experimental engine (hot)	Temp. deg. F.......	60	65	67	85	113	145	212	265	420	635	715	872	920
	Press. lb. gage......	—8.2	8.1	7.7	—7.2	—5.8	—4.1	—0.5	5.2	17.2	45	90	172	215
Gas engine (cold)	Temp. deg. F.......	60	60	62	65	72	85	127	155	200	255	340	415	452
	Press. lb. gage......	0	0	0	1	1.4	3 1	5	10	13	24	39	80	90,
Gas engine (hot)	Temp. deg. F.......	260	260	265	268	277	295	325	364	426	531	647	752	802
	Press. lb. gage...	0	0	0	1	1.4	3 1	5	10	13	24	39	80	90
Wentworth experimental engine overload (cold)	Temp. deg. F.	60	64	68	75	85	106	140	210	290	452	627	790	918
	Press. lb. gage..	0	0.3	0.7	1	2.3	7.8	14	32	46	98	203	383	500

Degrees of Crank Angle		Combustion										
		375	390	405	420	435	450	465	480	495	510	525
Diesel engine (cold)	Temp. deg. F.	1170	1790	1840	2040	1740	1530	1325	1230	1170	1105	1090
	Press. lb. gage	501	438	270	190	122	80	56	44	36	32	30
Diesel engine (hot)	Temp. deg. F.	1790	2660	2720	2660	2580	2300	2010	1880	1800	1710	1690
	Press. lb. gage	501	438	270	190	122	80	56	44	36	32	30
Wentworth experimental engine (hot)	Temp. deg. F.	1570	1585	2000	1750	1440	1210	1140	990	940	915	900
	Press. lb. gage	270	200	120	65	41	32	22	14	10	8	7
Gas engine (cold)	Temp. deg. F.	2500	2480	2380	2160	2050	2010	1850	1780	1660	1610	1507
	Press. lb. gage	305	260	190	143	111	81	70	60	45	35	20
Gas engine (hot)	Temp. deg. F.	3540	3520	3475	3200	3030	2960	2760	2640	2490	2410	2320
	Press. lb. gage	305	260	190	143	111	81	70	66	45	35	20
Wentworth experimental engine overload (cold)	Temp. deg. F.	1065	1940	2555	2680	2505	2370	2190	2200	2195	1955	1925
	Press. lb. gage	470	358	242	165	120	90	78	68	55	40	30

Degrees of Crank Angle		Exhaust												
		540	555	570	585	600	615	630	645	660	675	690	705	720
Diesel engine (cold)	Temp. deg. F.......	600	450	450	450	450	450	450	450	450	450	450	450	450
	Press. lb. gage......	15	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Diesel engine (hot)	Temp. deg. F..... .	1465	988	988	988	988	988	988	988	988	988	988	988	988
	Press. lb. gage.... .	15	0.5	0 5	0.5	0 5	0 5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Wentworth experimental engine (hot)	Temp. deg. F....	890	890	890	890	890	890	890	890	890	890	890	890	890
	Press. lb. gage..	0	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Gas engine (cold)	Temp. deg. F.... .	1312	919	919	919	919	919	919	919	919	919	919	919	919
	Press. lb. gage.. .	0.3	0.3	0.3	0 3	0.3	0.3	0.3	0.3	0.3	0 3	0.3	0.3	0.3
Gas engine (hot)	Temp. deg. F.. . .	1990	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450	1450
	Press. lb. gage. ..	0.3	0.3	0.3	0.3	0.3	0 3	0 3	0 3	0.3	0.3	0.3	0 3	0.3
Wentworth experimental engine overload (cold)	Temp. deg. F.. .	1560	1340	1160	1160	1160	1160	1160	1160	1160	1160	1160	1160	1160
	Press. lb. gage	15	5	0	0 3	0 3	0 3	0 3	0.3	0 3	0 3	0 3	0 3	0 3

Degrees of Crank Angle		Suction										
		15	30	45	60	75	90	105	120	135	150	165
Diesel engine (cold)	Temp. deg. F.	60	60	60	60	60	60	60	60	60	60	60
	Press. lb. gage	0	—0.5	—0 5	—0 5	—0.5	—0 5	—0 5	—0.5	—0 5	—0 5	0
Diesel engine (hot)	Temp. deg. F.	600	550	400	300	290	280	270	260	260	260	260
	Press. lb. gage	0	—0 5	—0.5	—0.5	—0.5	—0.5	—0.5	—0 5	—0 5	—0 5	0
Wentworth experimental engine (hot)	Temp. deg. F.	700	600	400	300	212	145	135	84	67	65	60
	Press. lb. gage	0	0.5	—0.5	—0.5	—0.5	—4 1	—5.8	—7 2	—7.7	—8.1	—8.2
Gas engine (cold)	Temp. deg. F.	60	60	60	60	60	60	60	60	60	60	60
	Press. lb. gage	0	0.5	—0.5	—0 5	—0 5	—0 5	—0 5	—0.5	—0.5	—0.5	0
Gas engine (hot)	Temp. deg. F.	1000	750	500	400	360	300	290	280	270	260	260
	Press. lb. gage	0	—0.5	—0 5	—0 5	—0.5	—0 5	—0.5	—0 5	—0 5	—0.5	0 0
Wentworth experimental engine overload (cold)	Temp. deg. F.	60	60	60	60	60	60	60	60	60	60	60
	Press. lb. gage	0	—0 3	—0 3	—0 3	—0 3	—0 3	—0.3	—0 3	—0 3	—0 3	—0 3

before being rejected, and as much as possible of this waste heat will be converted into steam. The energy from the boiler will be used to run the auxiliaries and, if the idea is correct, to run a separate steam propelling plant. The exhaust from all steam units will be returned to a condenser, where at last the remaining heat units will be abandoned as unavailable energy.

OBITUARY

JOSEPH G. McCOLLUM

Joseph Grant McCollum, superintendent of construction of the Essex power station of the Public Service Electric Co., at Point-no-Point, on the Passaic River, died from pneumonia at the Newark (N. J.) Private Hospital, Jan. 13, at the age of 29.

He was graduated from Cornell University in the class of 1909. He was for a time with Westinghouse Church Kerr & Co. in New York, and early in 1914 removed to Newark, N. J., and became superintendent of construction at Burlington for the Public Service Electric Co. of New Jersey.

F. W. JENKINS

On Thursday, Jan. 14, 1915, Frank William Jenkins died at his home in Brooklyn, N. Y., from complications due to old age. He was widely known as an expert in hydraulics and was connected with the Henry R Worthington Pump Co. for over fifty years.

Mr. Jenkins was born in Hudson, N. Y., Feb. 26, 1832, moved to Brooklyn at the age of 14, and spent the remainder of his life there. Many inventions and improvements in steam pumps and hydraulic engineering are the products of his genius. He also occupied a high place in the civic and municipal life of the comunity in which he lived. Two daughters survive him.

PERSONALS

William Naylor, after a service of 44 years in the engineering department of Marshall Field & Co., has retired from his position as chief engineer. He was born in Lancashire, England, Jan. 4, 1833, was apprenticed at the age of 9 to the London & North Western R.R. shops at Leeds, and was promoted to engine runner at the age of 19. In 1859 he was driving the "Manchester-Liverpool Flyer," which occupation he left to come to America, arriving at New Orleans after a voyage of seven weeks. He worked at New Orleans, Jackson and Memphis for short periods and in 1860 settled in Mt. Carmel, Ill., and engaged in the lumber-sawing business. He moved to Warrensburg, Mo., in 1865, and in 1866 to Chicago, where he entered the employ of Field, Leiter & Co., now Marshall Field & Co., in 1871. He is father of Past-President Chas. Naylor, of the N. A. S. E., of which organization he is himself an active member, being treasurer of the Robert Fulton Association No. 28, of Illinois, and is known to, and esteemed by, almost everyone in Chicago who is in any way connected with power-plant engineering.

NEW PUBLICATIONS

OIL FUEL, ITS SUPPLY, COMPOSITION AND APPLICATION. By Edward Butler. Published by Charles Griffin & Co., Ltd., London, and J. B. Lippincott Co., Philadelphia, 1914. Size 5x7½ in.; 328 pages; illustrated.

After introductory chapters on the origin, production and economic aspects of oil fuel, the author reviews some of the early work with oil fuel, compares the steam-, air- and pressure-jet methods and then proceeds to descriptions of the burners in use today for steam boiler furnaces. Oil fuel for marine and locomotive purposes is dealt with at length and its use in metallurgical work is also considered. Very wisely, it would seem, no attempt has been made to touch upon the internal combustion engine, as this subject is so broad in itself that any treatment in a book of this kind would necessarily be incomplete.

THE ANALYSIS OF COAL WITH PHENOL AS A SOLVENT. By S. W. Parr and H. F. Hadley. Bulletin No. 76 of the University of Illinois. Paper; size, 6x9 in.; 41 pages, illustrated. Price, 25c.

As far back as 1851, experiments were made on coal for the purpose of dissolving those constituents of the coal which were soluble in certain chemicals, and from time to time different investigators have taken up the problem. The experiments by the authors of this bulletin have been made for the purpose of overcoming some of the objections to both the chemical and the proximate analysis.

It will be understood that the action of the chemical—phenol in this case—must be that of a true solvent and must not cause chemical changes either in its own structure or in that of the components of the coal. While there are several chemicals that will dissolve the solvent components of coal, phenol is best.

It does not seem that this method of coal analysis will be adopted generally in power plants, but our readers who are interested in that subject will find this bulletin well worth while.

STEAM CHARTS. By F. O. Ellenwood, Assistant Professor of Heat Power Engineering, Cornell University. Published by John Wiley & Sons, New York. Cloth, 7x9¾ in., 91 pages; 18 charts; 9 figures. Price, $1.

This book is intended to be of assistance to engineers and students when making calculations involving wet or superheated steam, and for that purpose the author has presented a set of charts convenient to handle and easy to read without extending the size of the charts beyond the dimensions of the page.

An introductory chapter sets forth the fundamental principles of pressure-volume and temperature-entropy diagrams, and another chapter is devoted to describing the preparation and use of the steam charts and a table of velocities, the scale of volumes being plotted from the values given by the steam tables of Marks and Davis.

A third introductory chapter defines atmospheric pressure and Baumétric corrections. There are an index chart, total, heat volume chart, external-work-volume chart, correction of mercury column for temperature and chart of correction of barometric readings due to change in elevation. There are also tables of correction of barometric readings and for capillarity, and tables of density of mercury and of theoretical velocities of steam expanding adiabatically in a frictionless nozzle.

Fifty illustrative problems are given with their solutions. These, together with the greater convenience of the charts over the large scale folders such as are usually employed for steam charts, render the task of making steam computation more inviting to the beginner and provide a work well adapted to the purposes of a handbook for engineers for data on the properties of steam and for checking methods of performing computations.

BUREAU OF STANDARDS PUBLICATIONS

Three instructive papers have recently been issued by the Bureau of Standards under title of "Measurement of Standards of Radiation in Absolute Value," "Various Modifications of Bismuth-Silver Thermopiles Having a Continuous Absorbing Surface," and "An Experimental Study of the Koepsel Permeameter," the last being an instrument for measuring the magnetic properties of iron and steel.

BOOKS RECEIVED

AMERICAN HANDBOOK FOR ELECTRICAL ENGINEERS. By Harold Pender. John Wiley & Sons, Inc., New York. Morocco leather; 2023 pages, 4¼x7 in.; fully illustrated; tables. Price, $5.

MACHINE SHOP PRACTICE. By Wm. J. Kaup. John Wiley & Sons, Inc., New York. Cloth; 199 pages, 5¼x7¾ in.; 158 illustrations. Price, $1.25.

HOW TO RUN AND INSTALL GASOLINE ENGINES. By C. Von Culin. Norman W. Henley Publishing Co., New York. Paper; 98 pages, 3¼x6 in.; illustrated. Price, 25 cents.

INSTALLING EFFICIENCY METHODS. By C. E. Knoeppel. The "Engineering Magazine," New York. Cloth; 258 pages, 7x10¼ in.; 103 illustrations. Price, $3.

TRADE CATALOGS

Burd High Compression Ring Co., Rockford, Ill. Directory of piston ring sizes. Illustrated, 68 pp., 4½x6½ in.

Elliott Co., 6910 Susquehanna St., Pittsburgh, Penn. Bulletin H. Alarm water columns. Illustrated, 8 pp., 7x10 in.

Harrison Safety Boiler Works, Philadelphia, Penn. Catalog No. 601. Cochrane multiport valves. Illustrated, 72 pp., 6x9 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-K. Fuel oil and gas driven compressors. Illustrated, 24 pp., 6x9 in.

General Electric Co., Schenectady, N. Y. Bulletin No. 42,010. Small turbo-generator sets. Illustrated, 14 pp., 8x10½ in. Bulletin No. 42,300. Steam engine-driven generating sets. Illustrated, 12 pp., 8x10½ in. Bulletin No. 45,602. Lightning arresters for series lighting circuits. Illustrated, 8 pp., 8x10½ in.

POWER

Vol. 41 NEW YORK, FEBRUARY 2, 1915 No. 5

The Leak

By R. T. Strohm

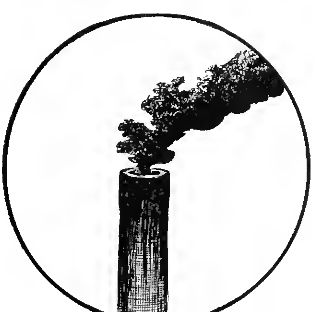
THE boss was good and proper mad, of that there was no doubt,
When he came in the other week to see the engineer.
He hardly got inside the door before we heard him shout
"Just look at this report on cost of power for the year!
The way you're running up expense has simply got to stop,
Or you'll be gallivanting 'round in search of pastures new.
Another year like this one was will make us close the shop.
Get busy, now, and find the leak—the thing is up to you!"

THE engineer was young and fresh, an overbearing snob,
Who always tried to make us feel that he was mighty wise;
So when we heard the sudden news that he might lose his job,
We nudged each other in the ribs and slyly winked our eyes.
For we were in the boiler room, to cart and heave the coal,
To clean the tubes and haul the ash, and tend the water, too;
And every mother's son of us, deep in his inmost soul,
Felt pretty sure that half the heat was going up the flue.

HE snooped around in every nook and tested all the traps,
To see that they were working well and steam could not get by;
He tinkered with the bearings and adjusted all the caps,
Believing that the friction loss was running rather high;

"The boss was good and proper mad"

"The engineer was young and fresh"



"Half the heat was going up the flue"

He packed the engines and the pumps to make them good and tight,
And then relined the shafting till it ran exactly true;
But we that fed the furnaces from early morn to night
Were puzzled why he never thought to test for CO_2.

HE polished all the pieces of his indicator kit
And took a set of cards from every engine on the floor;
He looked them over carefully and set the valves a bit,
And then he fixed the rig again and took a dozen more;
He overhauled the coverings on pipes conveying steam,
And every broken section was replaced at once with new;
He tried to lower running costs by every kind of scheme,
But never thought to make a test of what went up the flue.

HE fussed and fumed and stewed around about a week or so,
But still the coal-pile dwindled down alarmingly each day;
So finally we told him what we thought he'd like to know,
And said he'd better find just how much heat we threw away.
That hint was what he needed, for, instead of cutting loose,
He clinched his job still tighter, and he saved our bacon, too.
And thus he proved the adage that it's precious little use
To save around the engine while you're wasting up the flue.

Municipal Pumping Stations of Detroit

By Thomas Wilson

SYNOPSIS—Development of water-works from one unit in 1876 to ten units at present date, having a combined capacity of 267,000,000 gal. in 24 hr. New station containing three units just completed. Operating data and costs for the past year.

For 38 years Detroit's water-pumping station has been located in Waterworks Park at the eastern extremity of the city, between Jefferson Ave. and the river. Starting with one unit, the development to present capacity has been interesting. New units were installed as required until seven are now contained in the old station and three in a new building in which space has been provided for a total of six. Individually, each unit shows an increased duty over its predecessor, and collectively, the entire installation indicates the development in the art.

In the installation of large units Detroit has been a pioneer in pumping engines as well as in boilers, and it may be of interest to follow the plant through from the beginning. In 1876 a building large enough for two units was erected, and the first unit, a compound beam double-acting pumping engine having a capacity of 24,000,000 gal. per 24 hr., was installed. The cylinder dimensions were 42 and 84 by 40¼ by 72 in. In those days a compound engine was a novelty, and as the unit had almost double the capacity of any pump then in existence, it created wide interest and, like the Centennial engine, was one of the attractions in the engineering world. It showed a duty of 87,000,000 ft.-lb. on 100 lb. of coal, the steam pressure being 65 lb. gage and the speed 10½ r.p.m. It was the only pump of the kind ever built by the Detroit Locomotive Works. That it was of good design and well made is shown by the fact that it is still in active service.

A unit of similar design and of equal capacity and duty was installed in 1880. The dimensions were 46 and 84 by 41 by 72 in. Six years later another unit was required and the east end of the station was enlarged to make room for it. At this time Detroit's original pumping station was dismantled and as many parts as possible were saved for the new unit, which was to have a capacity of 30,000,000 gal. The pump thus had a capacity 25 per cent. greater than its predecessors, and was one of the "giants" of its day. It had compound steam cylinders and a water plunger of the same diameters as unit No. 2, but the stroke was 84 in. and the speed higher. The economy was also greater, as the pump showed a duty of 100,000,000 ft.-lb. In 1898 the high-pressure end was redsigned for a 35-in. high-pressure cylinder, so that the pump could utilize steam at 135 lb. pressure instead of 65 lb., the pressure formerly carried.

After an interval of seven years increasing demands called for a fourth unit, which was put in service in 1893. The west end of the station was enlarged to receive it. The pump was the first triple-expansion unit for the station, with cylinders 28, 48 and 74 by 36 by 60 in. It had a capacity of 24,000,000 gal. and was a duplicate of one pumping engine installed in Milwaukee and three in Chicago at the same time. Outside-packed plungers were another departure. A 30-day test by Professor Barrus on this unit showed a duty of about 130,000,000 ft.-lb., an increase in economy of 33⅓ per cent. over the most efficient of the compounds which had been previously installed.

Up to this time the pumps had been working against a head of 140 ft., or 60 lb. Need was felt for a higher pressure, so the next units were designed to operate against a head of 230 ft., or nearly 100 lb. pressure. The east end of the station was again enlarged, this time for three units. In 1900 two 25,000,000-gal. pumps were installed. They were triple-expansion units, 34, 62 and 92 by 36½ by 72 in., which on test showed a duty of 148,000,000 ft.-lb. These two units, as well as Nos. 3 and 4, operate on 135-lb. steam pressure. All up to this point had been equipped with jet condensers giving a vacuum of 26 in., the air pump being driven from the main shaft.

Fig. 1. New Pumping Station in Waterworks Park, Detroit

Eleven years passed before the seventh unit was needed. It was ordered in 1911 and was built and installed in the remarkable time of eight months after the contract was signed. The capacity was 25,000,000 gal. and the type vertical triple-expansion as before. The dimensions were 32, 60 and 90 by 37½ by 66 in. Since the last previous installation a surface condenser in the suction of the pump had become common practice, and was used in the present case. A surface of 2000 sq.ft. exposed to all of the water passing to the pump produced a vacuum of 28 in. and helped to boost the duty of this unit to 150,000,000 ft.-lb. and cut the steam consumption to 10.3 lb. per i.hp.-hr. This arrangement naturally eliminated the circulating pump.

Boiler Room

In the boiler room equal progress was made in the size and efficiency of the equipment. Old firebox marine and return-tubular boilers, hand-fired, have been replaced with water-tube boilers of horizontal and vertical types equipped with top feed or underfeed stokers. There is now a total of 15 boilers aggregating 4399 hp. There are four 225-hp. horizontal boilers on which the pressure has been cut to 110 lb., three 333-hp., four 225-hp. and four

400-hp. vertical boilers, all carrying a working pressure of 165 lb. The 400-hp. boilers were installed in 1913. Each has 4000 sq.ft. of heating surface and 64 (later reduced to 50) sq.ft. of inclined grate surface. The high ratio of 80 to 1 was made possible by the excellent quality of coal used, which is Meadow Brook run-of-mine averaging 14,300 B.t.u. per lb. and 6 to 7 per cent. ash. Four brick stacks for the 15 boilers supply natural draft. a common header tapped to each boiler. Feed-water regulators control the supply to the boilers, and as the pumps operate in unison with the main units, safety valves are installed on the discharge pipes to prevent excessive pressure and allow surplus water to flow back to the hotwell. Feed-water heaters are not used, as there is no auxiliary steam. This completes the equipment of the old station, which was given in some detail so that it might be known

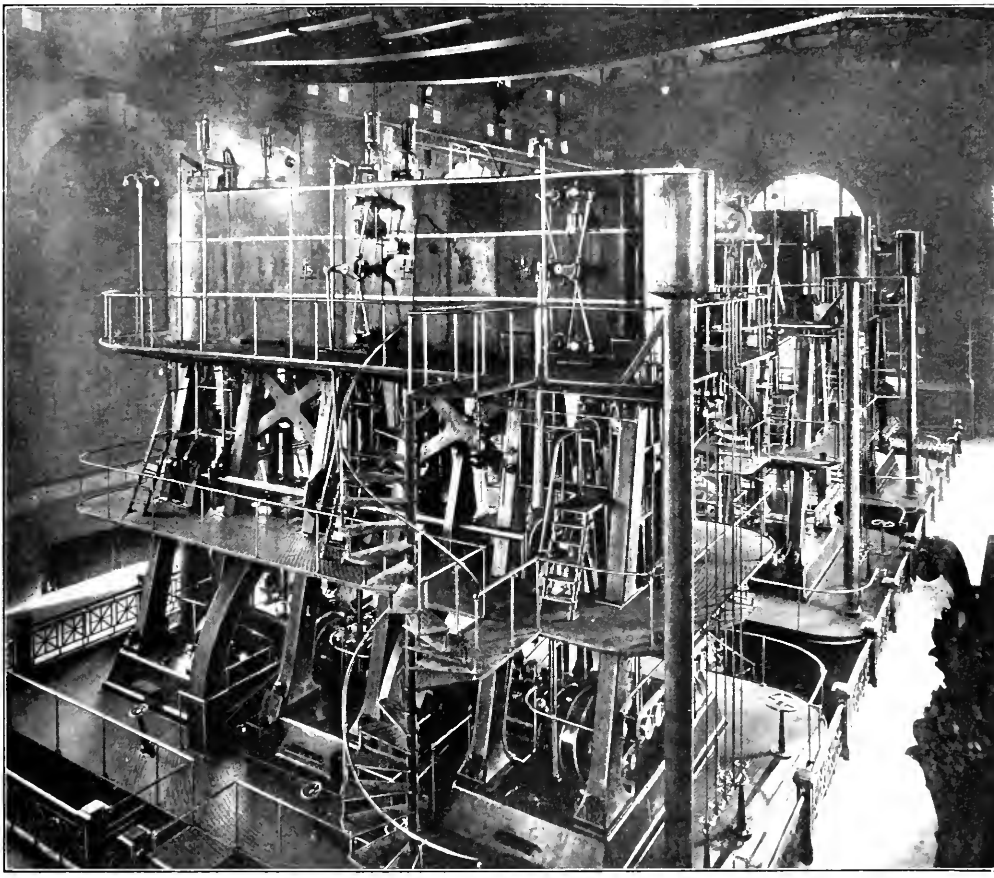


Fig. 2. Three 30,000,000-Gal. Pumping Engines Occupying Half the Station

Gages to measure the draft, a steam-flow meter and a CO_2 recorder make it possible to check results obtained from the boilers.

Fuel is obtained by boat during the navigation season. It is unloaded into a hopper, crushed, and conveyed to storage sheds of 12,000 tons capacity. Industrial cars carry the coal into the boiler room where, with the exception of the new boilers, it is shoveled into the magazines of the stokers. For the late addition a half-ton air hoist transfers the coal from car to stoker.

Water from the jet condensers and the steam jackets of the engine cylinders is discharged to hotwells at a temperature of 140 deg. and fed to the boilers by single-acting pumps operated from the walking beams or the main shafts of the first six units. The pumps discharge into from what type of machines the operating data presented later were obtained.

New Pumping Station

In 1909 the water commission broke ground for the new station which rapidly increasing demands made necessary. The building, which has just been completed, was planned for six units, being 300 ft. long and 75 ft. wide. It is one of the finest structures of its kind in the country. Concrete foundations, walls of cut stone and pressed brick, a marble entrance, large bronze doors, electroplated railings around the pits, massive lighting fixtures, slate and terrazo floors and white enamel brick walls in the basement are some of the features which helped to make the building cost half a million dollars.

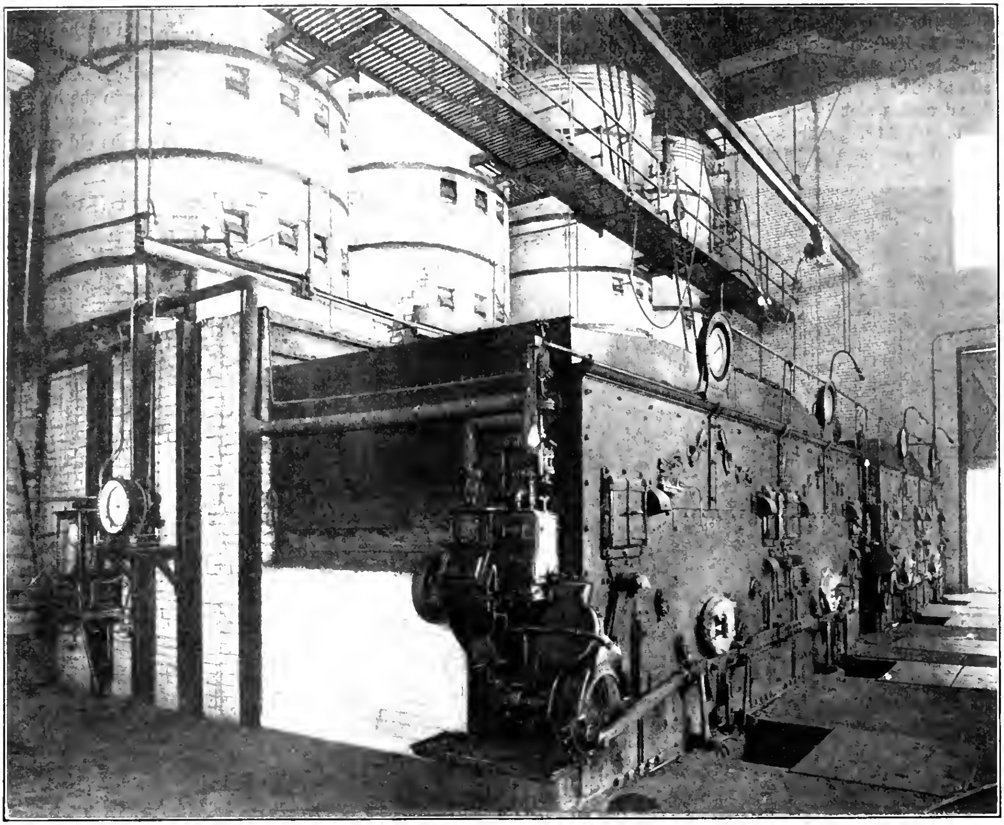


Fig. 3. Four 400-Hp. Vertical Water-Tube Boilers Installed in 1913

Three of the six units for this building have just been erected and put into service. All are triple-expansion engines of 30,000,000-gal. capacity, with cylinders 32, 60 and 90 by 39¾ by 66 in. The pumps are of the double-flow type and each has on the suction side a condenser having 2000 sq.ft. of surface. Hydraulically operated gate valves 48 in. in diameter are fitted to the suction and discharge pipes. Each pump weighs approximately 900 tons, of which 70 tons is accounted for by two 20-ft. flywheels. The hollow steel shaft is 22 in. in diameter. A feature is the making of the water ends entirely of cast steel. Extra strength was required, as the water is delivered directly to the mains, with no intervening reservoirs. No official tests have been conducted, but the duty guaranteed on 1000 lb. of saturated steam is 172,000,000 ft.-lb., and 180,000,000 ft.-lb. is expected by the builder. The cost of the pumping equipment was close to $3700 per million gallons of daily capacity.

PRINCIPAL EQUIPMENT OF DETROIT WATER-WORKS

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Pumping engine	Compound, beam	42x84x40¼x72-in.	Main unit	Steam pressure 65 lb., head 60 lb.	Detroit Locomotive Works
1	Pumping engine	Compound, beam	46x84x44x72-in	Main unit	Steam pressure 65 lb., head 60 lb.	Riverside Engine Works
1	Pumping engine	Compound, beam	35x84x44x84-in.	Main unit	Steam pressure 135 lb., head 60 lb.	Riverside Engine Works
1	Pumping engine	Triple-expansion	28x48x74x36x60-in	Main unit	Steam pressure 135 lb., head 60 lb.	E. P. Allis & Co.
2	Pumping engines	Triple-expansion	34x62x92x36¾x72-in	Main unit	Steam pressure 135 lb., head 100 lb.	Allis-Chalmers Co.
1	Pumping engine	Triple-expansion	32x60x90x37½x66-in	Main unit	Steam pressure 165 lb., head 100 lb.	Allis-Chalmers Co.
3	Pumping engines	Triple-expansion	32x60x90x39¾x66-in	Main unit	Steam pressure 165 lb., head 100 lb.	Bethlehem Steel Co.
6	Condensers	Jet		Serving main units	26-in. vacuum	Same as pumping engines
6	Air pumps	3 single-acting, 3 double	Varying sizes	Serving jet condensers	Direct-connected—Speeds 12 to 21 r.p.m.	Same as pumping engines
4	Condensers	Surface	2000 sq.ft.	Serving main units	28-in. vacuum	3 Bethlehem engines—Worthington condenser; 1 Holly engine—Holly condenser
6	Pumps	Single-acting	Varying sizes	Boiler feed	Mechanically driven by main units	Same as main units
3	Boilers	Vertical water-tube	333 hp.	Generate steam	Steam pressure 165 lb., stokers	Wickes Boiler Co.
3	Stokers	Jones underfeed		Serving 333-hp. boilers		Under-Feed Stoker Co. of America
4	Boilers	Wood type	225 hp.	Generate steam	Steam pressure 110 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed		Serving wood boilers		Murphy Iron Works
4	Boilers	Vertical water-tube	225 hp.	Generate steam.	Steam pressure 165 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed		Serving 225-hp. boilers		Murphy Iron Works
4	Boilers	Vertical water-tube	400 hp.	Generate steam	Steam pressure 165 lb., stokers	Wickes Boiler Co.
4	Stokers	Top feed	50 sq.ft. grate	Serving 400-hp. boilers		Detroit Stoker Co.
1	Air hoist	Motor, air	5-ton	Serving 400-hp. boilers		Detroit Machine & Hoist Co.
2	Cranes	Travelling	30 and 20 tons	In new and old stations		Northern Engineering Works

Although an independent boiler room and coal-storing sheds are contemplated for the new station, at present steam is supplied from the boiler room of the older plant, the new 400-hp. boilers giving ample capacity; a total of 4399 boiler-horsepower in 15 boilers supplying 10 pumping engines having a combined capacity of 267,000,000 gal. in 24 hr. against a varying head running up to 100 lb. Thus, for a million gallons in 24 hr., 16.5 boiler-horsepower has been provided. Working on 8-hr. shifts, 65 men are employed for both stations.

Operating Data

Data available from the Board of Water Commissioners for the year ended June 30, 1914, are presented in the following: For the year the total water consumption was 40,724,947,672 gal. pumped to an estimated population of 652,000 against an average head of 53.2 lb. This reduces to an average daily consumption of 111,575,200 gal. and an average daily per capita of 171.4 gal. Of the total, 11,257,814,355 gal. was pumped on the high service against an average dynamic head of 63.7 lb., and on the low service 29,467,133,317 gal. against an average head of 47.4 lb. On Feb. 13, the maximum day, the pumpage was 145,607,536 gal., and on Dec. 25, the minimum day, 85,187,023 gal. For the high service the average daily was 30,843,327 gal. and for the low service 80,731,872 gal.

Each unit is equipped with a Venturi meter, which, on an average, reads to within 5 per cent. of the pump displacement. In the above figures an allowance of 6 per cent. slip was made for the three compounds and one triple-expansion engine and 5 per cent. on the other units.

During the year 46,874,865 lb. of Meadowbrook bituminous run-of-mine coal was burned. Including unloading from the boats, the price averaged $2.515 per ton. Per pound of coal 869 gal. was pumped against an average head of 53.2 lb. or 123.7 ft. The average duty per 100 lb. of coal was 88,906,868 ft.-lb. The pumping cost

COST OF PUMPING BASED ON STATION EXPENSES

Item	Amount per Year	Cost per Mil. Gal.	Cost per Mil. Gal. Raised 100 Ft.
Pay roll	$67,533.31	$1.66	$1.35
Fuel	59,103.57	1.45	1.18
Oil and waste	1,446.76	0.04	0.03
Supplies and repairs	4,359.97	0.11	0.09
Miscellaneous	3,556.77	0.08	0.07
Totals	$136,000.38	$3.34	$2.72

based on station expenses is given in the accompanying table. The total for the year is $136,000.38. This reduces to $2.72 per million gallons raised 100 ft. Figured on total maintenance, the cost per million gallons was $6.23.

Smith, Hinchman & Grylls, of Detroit, were the architects and engineers for the new station. Theodore A. Leisen is general superintendent of the Board of Water Commissioners and H. W. Gould engineer-in-charge of the pumping station. To both of these officials we are indebted for the information contained in this article.

The Constant-Current Transformer

By John A. Randolph

SYNOPSIS—Principles and construction of the constant-current transformer, with a diagram of its connection to arc-light circuits.

On all series arc systems it is important that the current be maintained constant irrespective of how many lights may be turned on or off. This is accomplished on direct-current systems by varying the voltage of a special generator assigned to each circuit. However, on alternating-current systems the arc lines are generally connected to busbars supplying other circuits, hence the maintenance of the constant current must be accomplished without affecting the generator pressure on the busbars. To secure this result, a special form of transformer is used. It is similar to the ordinary static transformer, the principal difference being that one of its sets of coils is movable.

Construction

The general construction is shown in Fig. 1. The transformer contains two coils, a primary and a secondary, one of which (in this case the primary) is stationary, the other being movable. The coils encircle the middle leg of a laminated iron core of the double magnetic-circuit type, the length of the core being sufficient to allow the secondary to move up and down through the required range. The secondary is suspended on either side from a rocker-arm attached to a shaft, which in turn is connected at its middle point to another arm extending oppositely to the other arms and which carries an adjustable weight. An oil-filled dashpot is also attached to the shaft for the purpose of steadying the movements of the shaft and its accessories.

Operation

In analyzing the operation, consider two simple closed coils of wire P and S placed side by side with axes coincident, as shown in Fig. 2. If a current is passed through

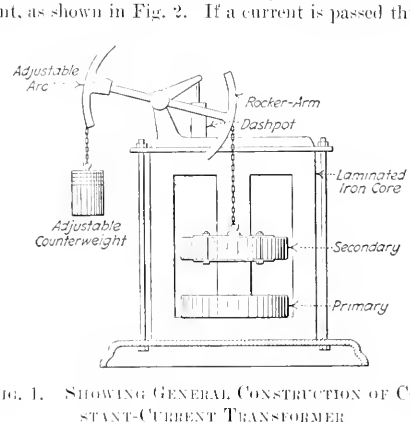


Fig. 1. Showing General Construction of Constant-Current Transformer

coil P, it will produce a magnetic field which will expand with the rise of the current. As these lines of force move outward they will be cut by the coil S. Now, according to the laws of electromagnetic induction, this cutting of lines of force will induce a current in the coil S, the direction of which will be opposite to that in coil P. This induced current will in turn set up a magnetic field of its own, but it will be opposite in polarity to that of coil P, owing to the opposite direction of the respective currents. A magnetic repulsion will therefore ensue between coils P and S. This action has been summarized in Lenz's law as follows: "In all cases of electromagnetic induction the reaction of the induced current is such as to tend to stop the motion which produces it." It is

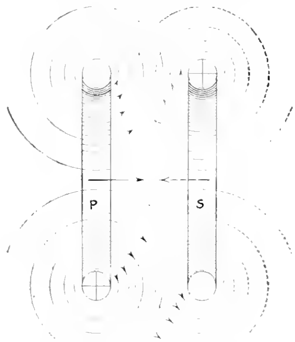


Fig. 2. Illustrating Principle of the Constant-Current Transformer

upon this principle that the operation of the constant-current transformer depends.

The counterweight in the two-coil type, shown in Fig. 1, is adjusted to exactly balance the weight of the secondary coil minus the repulsion, thereby rendering the transformer sensitive in its action and overcoming to a large extent the attraction of the force of gravity on the coil. The secondary coil is connected directly to the outgoing arc lines and the primary to the busbars. It can be said in general that the repulsion between the primary and the secondary will vary with the current in the latter. If, with the secondary coil in a given position, an additional number of lamps is turned on, the added series resistance will at once reduce the current for that particular instant. This will result in a decrease of the reaction of the secondary upon the primary, thereby allowing the secondary to fall nearer the primary, where the stronger field will induce the extra pressure necessary for maintaining a constant current in the secondary. The turning off of lamps will cause an instantaneous increase in the secondary current, which will increase the repulsion and cause the secondary to move to a weaker field, where the voltage will be lowered sufficiently to prevent any rise of current in the lamps that remain burning.

It will be observed in Fig. 1 that the arc on the end of the rocker-arm which carries the counterweight is adjustable. This is for the purpose of compensating for the difference in field strength in the various positions of the secondary. For instance, in a strong portion of the field, the difference between the weight of the secondary and the force of repulsion is less than in a weaker part of the field. Therefore, unless the counterweight were adjusted to balance this added weight in the weaker field, a stronger current would be necessary in the secondary to shift the latter to a position of equilibrium than would be required in the stronger field. The constancy of the current in the arc circuit would therefore be destroyed. However, by the adjustment of the arc from which the counterweight is suspended, the latter is caused to pull more heavily on the secondary in the weaker parts of the field, thereby enabling the secondary to maintain a constant-current value.

Three-Coil Type

As the capacity of the transformer increases, the number of ampere-turns in the primary and the secondary must also increase. Therefore, if only two coils were used, this would result in bulky windings and accessories which it would be difficult to handle and which would be likely, on account of their inertia, to lack the proper sensitiveness in operation. To obviate these difficulties three or four coils are used instead of two. In the three-coil type one primary and two secondaries are used, as in Fig. 3. Large pulleys are used instead of levers for the chain connections to the counterweights. The primary is stationary and is placed between the two secondaries, which are movable. Each secondary has two pulleys and a counterweight of its own and is entirely independent of the other in its action. Therefore, the repulsion and the distance between coil S_1 and the primary may be widely different from that between coil S_2 and the primary. Arc circuits may therefore be operated on the two coils in entire independence of each other. To increase the current in coil S_1, the external resistance remaining the same, the weight W_1 is reduced, allowing the coil by means of gravity to move nearer the primary. On the other hand, to increase the current in coil S_2, the counterweight W_2 must be increased in order to overcome the force of gravity and raise the coil to a position nearer the primary.

Four-Coil Type

In this transformer the primary and secondary are each composed of two coils, both coils of one set, either

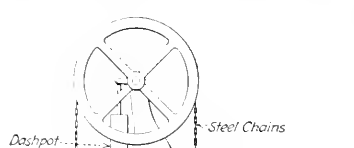


Fig. 3. Three-Coil Type

primary or secondary, being movable. In Fig. 4 is shown the arrangement of coils where the secondary is movable. The two primary coils are fixed at the extremities of the middle leg of the laminated iron core, the secondaries being free to move up and down in the intervening space. A repulsion between the primary and the secondary causes the two coils of the latter element to move toward the center of the core, thereby approaching each other. The movable coils are balanced against one another on two double levers, A and B, one end of lever A being connected to coil S_1 and the other to coil S_2. Likewise, lever B is connected to the other sides of coils S_1 and S_2. With this arrangement the secondaries will exactly balance each other when no external force is applied. This equilibrium, however, is destroyed as soon as a force of repulsion is set up between primary and secondary. To counterbalance this repulsion and regulate the movements of the secondaries, a counterweight is attached to the lever system. This has a tendency to bring the primary and the secondary coils together and is set to counterbalance the repulsion for a given current. As in the case of the two-coil transformer, the counterweight is supported on an adjustable arc to compensate for the difference in field strength in the various parts of the magnetic circuit.

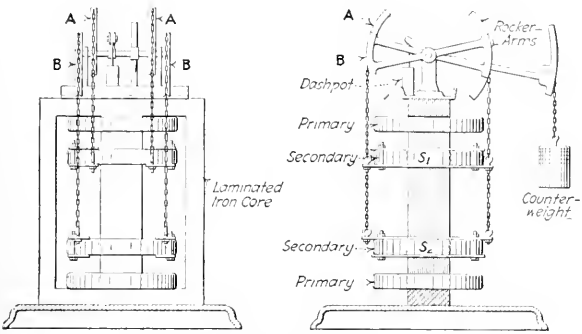


Fig. 4. Arrangement of Four-Coil Type with Movable Secondaries

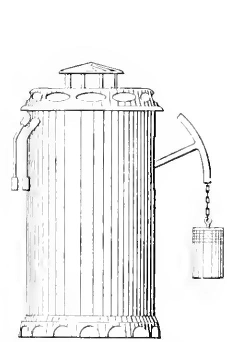


Fig. 5. Casing of Air-Cooled Transformer

Installation and Connections

Constant-current transformers are made in both the air-cooled and the oil-cooled types. When of the former pattern, all the parts except the counterweight are inclosed in a suitable sheet-iron case, as shown in Fig. 5, with liberal openings at the top to provide the necessary ventilation. Large openings are also left in the bedplate for the same purpose. In the oil-cooled type all the interior parts are placed in a tank and covered with oil, its external appearance being similar to that of the ordinary oil-cooled static transformer.

A diagram of connections commonly followed in the use of the constant-current transformer on three-phase systems is shown in Fig. 6. In the case shown the transformers are of the larger type containing two primaries and two secondaries, and the windings are connected for full load. However, it is sometimes desired to operate on partial loads, under which conditions, owing to the inductance of the primary coils, the power factor would be considerably reduced were the full winding used. To obviate this difficulty and thus maintain the efficiency of the system, taps are provided on the primary whereby part of the winding may be cut out, thus reducing the inductance and raising the power factor. Taps are also generally provided in the secondary coils for the same reason.

For opening and closing the primary circuit, either plug switches or oil switches may be used, but it is common practice to use the latter because of greater convenience in operation and the fact that they will open automatically if a sudden abnormal load is thrown on the transformer through a short-circuit, a ground, a lightning discharge or other disturbance. This tripping of the switch is accomplished by a relay which receives its

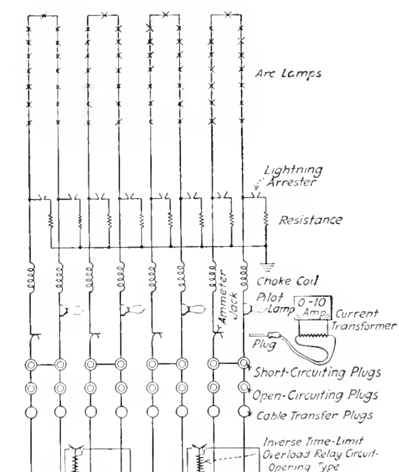


Fig. 6. Typical Diagram of Connections for Constant-Current Transformers

excitation from a current transformer in one of the primary leads.

Cable transfer plugs are provided in the secondary lines for the purpose of transferring the load on any line to another circuit. This provides a convenient flexibility in the system in case of repairs and other contingencies. The open-circuiting plugs are for the purpose of disconnecting the various circuits from their respective transformers. The short-circuiting plugs enable one of the two circuits of each transformer to be disconnected from the system without affecting the operation of the other.

An ammeter is provided on the arc panel to give current readings on the various circuits. To enable the customary low-voltage switchboard ammeter to be used, a current transformer is placed between the ammeter and the line, thereby preventing the high voltages of the line from coming in direct contact with the ammeter. The transfer of the instrument from line to line is accomplished by means of a plug attached to a flexible cord. The plug is inserted into a jack or receptacle attached to one leg of the respective circuits. As an additional means for providing current indications, a pilot lamp is connected in series with each circuit. This furnishes an approximate indication when the ammeter is disconnected.

Choke coils are placed in the various lines for the purpose of forcing lightning discharges to jump to ground through the lightning arresters, thus protecting the station apparatus.

It will be observed that larger wire is used on the primary side of the transformer than on the secondary. This is because on the heavier loads the primary, owing to its constant voltage, may be taking a heavier current than the secondary whose current never varies and is usually about ten amperes.

The efficiency of the constant-current transformer, when operating under full load, ranges from 94 per cent. in the smaller sizes to 96 per cent. in those of larger capacity.

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Examining the Examiner

In connection with the selection and appointment of the members of the Steam Engineers' and Boiler Operators' Licensing Bureau recently authorized by the State of New Jersey, the impression has been created that the questions asked by the Civil Service Commission of candidates to membership on the Board of Examiners were abstruse and technical to such a degree that no practical engineer could be expected to answer them. We have obtained from the Board the list of questions used at the examination which has been most discussed. Here they are. Is there a question in the list which one who aspires to be a state examiner of engineers should not be able to answer?

GENERAL QUESTIONS

A. State your experience, giving a complete record of where you have been working the last ten years; stating the size and make of each engine and boiler that you had under your jurisdiction, also giving name of the man, with his title, to whom you reported.

B. Write out five questions which you would suggest as desirable to use in examining a candidate for a first-class engineer's license.

C. Describe fully what you believe would be a correct method to use in forming different grades for engineers' and firemen's licenses.

Note: Candidates may ask examiner for explanation of any question that is not understood.

WRITTEN TECHNICAL QUESTIONS

1. Show by a sketch how a (one) steam main should be arranged in a boiler room in which there are two 200-hp., 160-lb. pressure boilers and two 100-hp. 100-lb. pressure boilers, so that at times all boilers might be put in service at 90-lb. pressure, or, each may be used at its respective pressure. Indicate all valves, reliefs, safetys, etc.

2. Calculate the horsepower of a boiler plant that burns 35 lb. of coal per square foot of grate per hour under boilers containing 10,000 sq.ft. of heating surface. Ratio of heating surface to grate surface = 50:1. Heat units in coal = 15,000 B.t.u. per pound. Efficiency of burning coal in boiler = 60 per cent.

3. Show by a sketch a triple-riveted butt-strap joint, and explain why longitudinal seams are butt-jointed and girth seams are lap-jointed.

4. A flat plate, 16x12 in. is held against a tank by four 1-in. bolts; what is the safe pressure to use in the tank, assuming factor of safety 5, tensile strength 50,000 and diameter root of thread = ¾ in.?

5. Show the arrangement of tubes, doors, etc., indicating the location of grate, smoke flue and baffles, for
   (a) Babcock & Wilcox cross-drum boiler
   (b) Stirling boiler
   (c) Heine boiler
   (d) Horizontal return-tubular boiler

6. (a) How many square feet of grate should there be for a 500-hp. boiler burning soft coal?
   (b) How large a piston should there be in an engine to develop 500 hp., if the mean effective pressure is 100 lb. and the piston speed is 250 ft. per min.?

7. If the eccentric of an engine is set so that it has an angle of advance of 28 deg., and if it is desirable to change the direction of rotation of engine, exactly how many degrees would you move the eccentric and in which direction, so that the angle of advance would still be 28 deg.?

8. How could you increase the operating speed of a flyball governing Corliss engine and yet have the "cutoff" the same?

9. If a cross-compound engine was out of adjustment how would you proceed to correct the steam distribution, so that equal work would be done on both cylinders?

10. Explain in detail how you would proceed to erect a girder-frame engine so that it would be level, true and aligned up to connect to a flange on a shaft already installed.

11. (a) What is meant by "clearance" of an engine?
    (b) How could you determine the location of the piston in respect to the ends of the cylinder, without removing the heads?
    (c) At which end of the stroke should the greater distance to the cylinder head be allowed? Why?

12. Show by a sketch how the exhaust-steam piping should be arranged for an engine operating with a surface condenser, indicating all valves, reliefs, etc.

Note: An examiner was present during the examination to explain any question that was not understood by candidates.

ORAL QUESTIONS

The candidate upon finishing the above set of questions will be examined orally on practical questions submitted to him in the engine and boiler room.

The candidate may answer the questions orally, or by demonstration.

Note: The general questions asked the last candidates were in connection with the following:

Cross-Compound Corliss Engine with Flyball Governor

1. Trace path of steam through the engine.
2. Explain the use of pipe pointed out (atmospheric relief pipe for high-pressure cylinder).
3. Examine, and explain completely the action of the engine governor.
4. Explain why the engine would not speed up if the governor belt broke
5. Explain the use and principle of operation of the dashpot.

High-Speed Vertical Compound Engine, Double Acting

6. Examine, and state type of engine.

Single-Cylinder Horizontal Engine, with Inertia Governor

7. Explain operation of the governor on the engine shown.

Vacuum Pump

8. Examine, and state what the piece of apparatus pointed out is used for.

Worthington Surface Condenser

9 Examine, and state what the piece of apparatus pointed out is used for.

Open-Type Feed-Water Heater

10. Examine, and state what the piece of apparatus pointed out is used for.

11. Is the heater shown an open or closed type?

Forced-Draft Apparatus (Engine and Centrifugal Fan)

12. Explain the use of the apparatus pointed out.

13. Does the engine have a lighter load with the forced-draft slides entirely closed, or with them entirely open?

Pressurlokd Water Gage

This water glass is so designed that the boiler pressure is used to lock the registering glass, which prevents the glass from flying should it break, and also prevents the escape of hot water and steam. A sectional view is shown in Fig. 1.

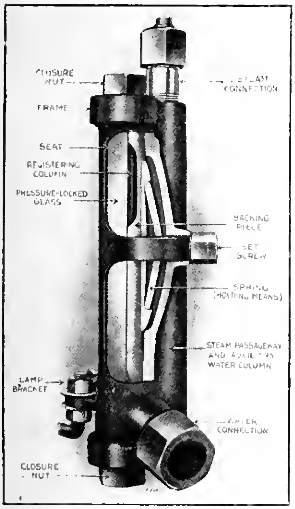


Fig. 1. Details of Pressurlokd Water Gage

The outfit consists of a metal-gage frame in which the registering glass *A*, Fig. 2, is held in place by a metal-sealed joint *C* to the seat *H*, by a back piece *N* and a holding spring *I*. The interior parts are held in place by a setscrew *L* which, when screwed down to its copper sealing washer, puts the proper tension on the spring. This tension, supplemented by the steam pressure at the points *D*, holds the backing piece and metal-incased glass to its seat on the inside of the frame, thus pressure-packing the metal-sealed joint. The steam pressure around the sides *EEK* and on the ends of the metal-incased glass locks the glass. Should the glass crack, the external pressure on the side and ends presses the shattered pieces closer together, which prevents leakage and the flying of glass.

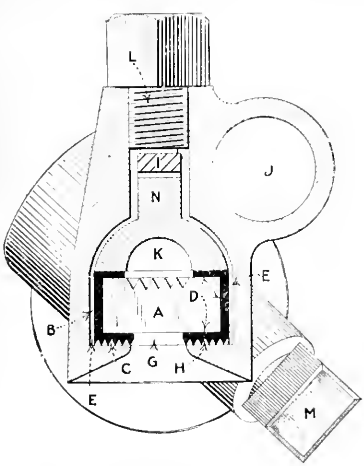


Fig. 2. Cross-Section of the Gage

The registering glass is incased with a sealing metal *B*, with the exception of the sight opening in front and the reflex part at the back. The metal frame seats on the serrated front *C* of the metal casing around the sight opening *G* inside of the frame. The spring which holds the glass to its seat permits it to expand and contract on its seat, thus relieving it of strains.

The space *K* back of the glass communicates with the water space *J*, and to the boiler through water and steam passageways. The steam and water connections to the boiler are straightway and, as no separate water column is used with the glass, straightway valves are used in the connections. Each valve is fitted with a semaphore handle, which shows whether the valve is open or closed. *M* is a cleaning plug.

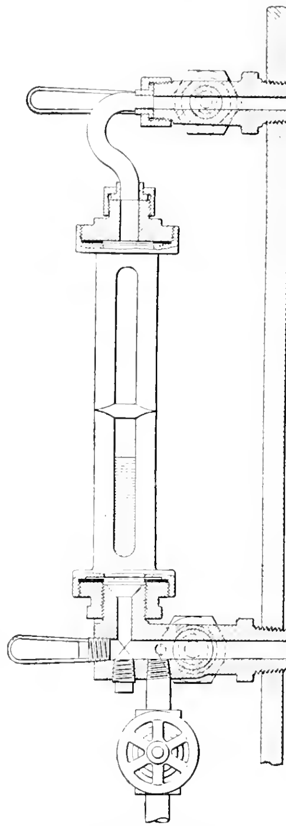


Fig. 3. Universal Gage for Any Boiler

The universal type of water glass, designed for any type of stationary boiler, is shown in Fig. 3. It contains the features of the locomotive type (Fig. 1) and is provided with a separate steam passageway, no water-column reservoir being used.

In case the glass breaks, the closures at the top and bottom of the frame are unscrewed, the setscrew is released and the old glass removed. When the new glass is inserted the setscrew is turned to its seat, copper gaskets inserted and the closures replaced.

These water gages are manufactured by the Prince-Groff Co., 50 Church St., New York City.

In "The Year's Review," published in our issue of Jan. 5, we failed to mention that the first unaflow engine built in this country under Professor Stumpf's patents and under the supervision of his American representatives, was erected at Auburn, N. Y., by the Ames Iron Works. We are glad to learn that the success of this first engine has led to numerous orders, and hope soon to be able to describe a considerable installation.

Power Requirements of Ammonia Compressors

By W. N. McKee

SYNOPSIS—An explanation of the use of charts for determining the power requirements of ammonia compressors for different suction and discharge pressures.

The power required to drive ammonia compressors is a constantly varying quantity due to the many operating conditions possible with such machines. Likewise, the amount of ammonia gas which it is necessary to circulate to produce certain amounts of refrigeration may vary in equally wide ranges.

The engineer who keeps records of costs in the operation of the plant has been compelled to go through a tedious routine of figures to maintain his daily records. This process becomes a burden when the engineer has a number of plants in various parts of the country. These plants must necessarily be operating under widely varying conditions which different climatic conditions make inevitable. To meet these conditions and include the greater number of variables, Charts I and II have been prepared and used by the writer in records covering the operation of a number of refrigerating plants.

Chart I is based on a table in a paper read by Thomas Shipley before the 1906 meeting of the American Society of Refrigerating Engineers. It shows "the minimum theoretical power utilized in a compressor to compress sufficient ammonia gas which, when liquefied at the pressure stated, will, upon being evaporated from the temperature corresponding to the given pressure to the temperature corresponding to the pressure in the evaporating system, do the same amount of work (have the

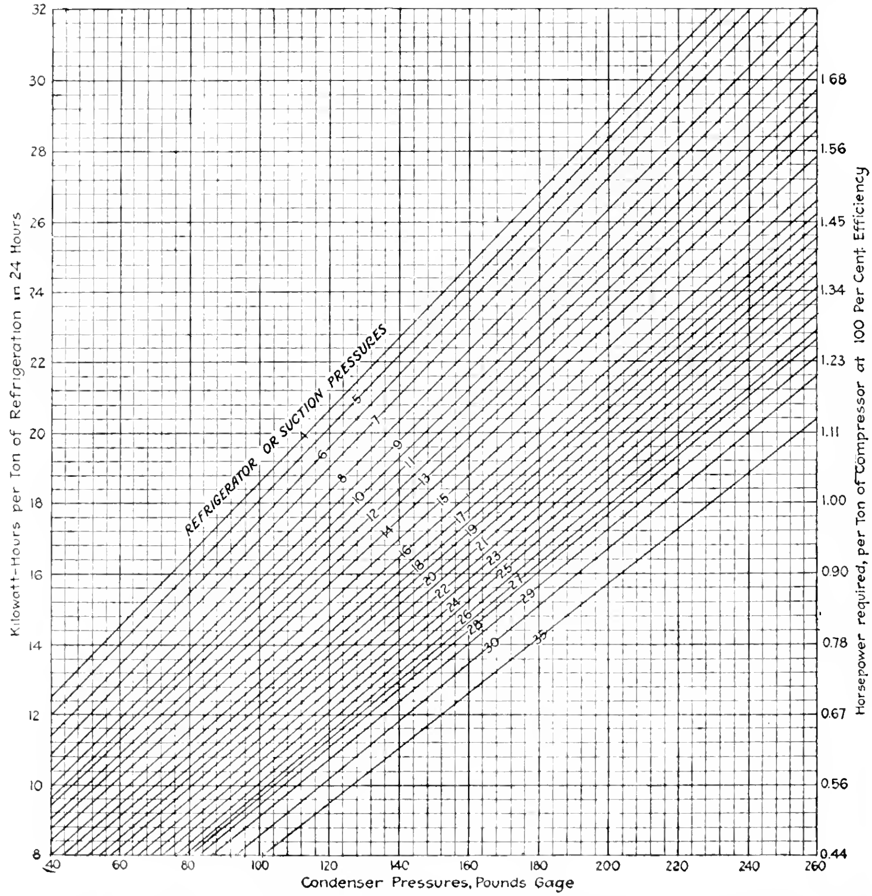


Chart I. Power Required per Ton Refrigeration for Various Suction and Condenser Pressures same cooling effect) as is done in the melting of one ton of ice." The kilowatt-hours, if the compressor is motor driven, to fulfill above conditions in a twenty-four hour period, is shown on the right, and the horsepower required is given on the left-hand margin. In each case the volumetric efficiency of the compressor and the efficiency of the motor are assumed as 100 per cent.

Chart II is to be used for closely estimating the work of the compressor or the amount of refrigeration produced over any period when the capacity and volumetric efficiency of the compressor are known.

pressor efficiency it will require 1.11 hp. per ton of refrigeration. Assuming 80 per cent. volumetric efficiency, then 1.11 divided by 0.80 and 15 per cent. added for friction load, gives nearly 1.6 hp. per ton refrigeration.

To the left it will be found that it requires 20 kw.-hr. per ton refrigeration in twenty-four hours at 100 per cent volumetric efficiency of the compressor. Then 20 divided by 0.80 volumetric efficiency and 15 per cent. added for friction, dividing this figure by 0.90 (approximate motor efficiency) gives 31.94 kw. per ton of refrigeration in twenty-four hours. The total current consumed,

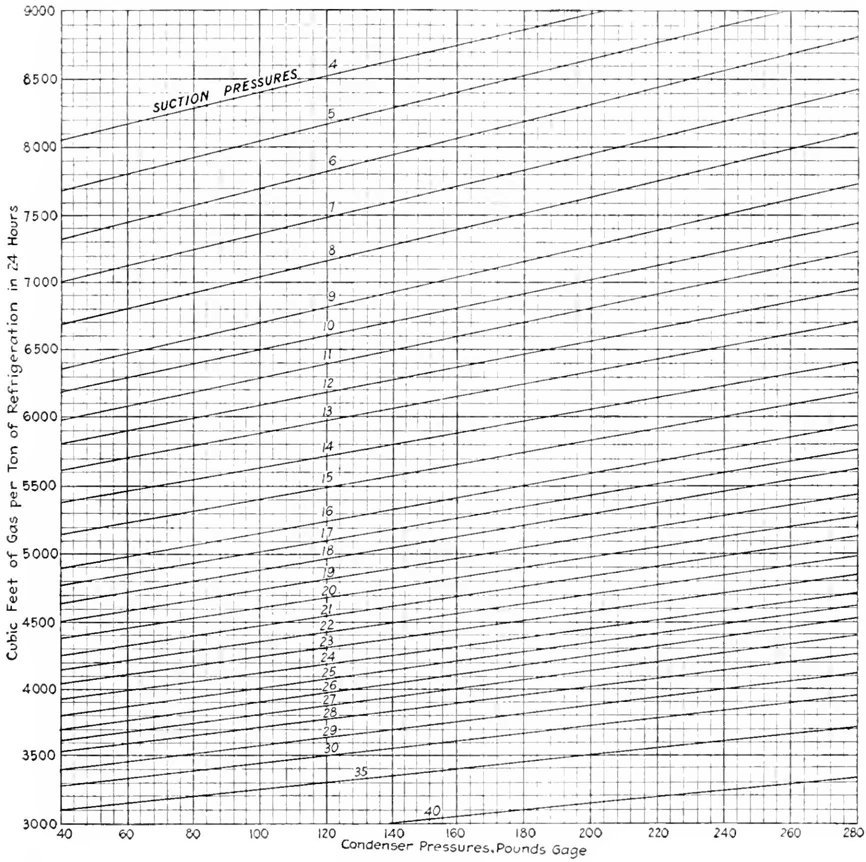


Chart II. Volumes of Gas per Ton Refrigeration for Various Suction and Condenser Pressures

This refrigeration as given is expressed in tons per twenty four hours. In the use of Chart I, take as an example an average condenser pressure of 180 lb. gage, average suction pressure, 16 lb. gage, to find the horsepower of the motor or engine required to drive a 100-ton compressor, also the current consumption on a twenty-four-hour load at the given suction and condenser pressures, follow the line for 180 lb. condenser pressure up, until it meets the 16-lb. suction-pressure line, and then along on the horizontal line to the right for the horsepower to drive and to the left for kilowatt-hours per ton for twenty-four hours. At 100 per cent. com-

31.94 times 100 (rating of the compressor) gives 3191 kw.-hr.

In the use of Chart II, it is necessary to know the capacity of the compressor over some definite period. If the machine starts and stops frequently or is of the automatic type without attendance, a revolution counter should be attached by which the capacity will be known over any period regardless of frequent stops.

As Chart II gives the number of cubic feet of gas required at 100 per cent. efficiency, it will be necessary to find the actual displacement of the compressor at the operating pressures for the proper period of time or number of revolutions. It is advisable to bring the displacement of the compressors to the same condition as stated in the chart, or 100 per cent. for a definite time, and thus obtain results by one division or multiplication.

The power required to drive small ammonia compressors of the single-acting type where the condenser pressures are not known but are for average refrigeration will be approximately as follows:

Capacity Tons	Horsepower Required	Capacity Tons	Horsepower Required
1	2	8	14
2	3½	9	15
3	5	10	17
4	7	15	25
5	8½		

In the table a friction load of 15 per cent. has been assumed. This would be the average for medium to large engine-driven units. For smaller units and belt drive the friction load may run greater, although the worst condition is seldom over 20 per cent.

If the ammonia liquid is cooled below the temperature corresponding to the condenser pressure, the tonnage will be increased thereby, but as this is not a usual operating condition it has not been included in the charts. The standard conditions have been assumed in which a ton of refrigeration is equivalent to the circulation of 26.7 lb. of anhydrous ammonia per hour at 15.67 lb. above the atmosphere, condensing pressure taken at 185 lb. gage pressure.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—We visit an uptodate power plant and Hunter discusses high- and low-priced machinery; he points out that cheap units are uneconomical in operation. Some examples of wasteful pumps and fan engines are given as well as the reason for their condition.

The next morning after our visit to Scalp Level I was up and ready for another tramp before Hunter put in an appearance. When we started out for the day, we headed for No. 35 colliery of the Berwind-White Coal Mining Co., at Windber, Penn. Here we found two 100-kw., three-phase, 25-cycle, 6600-volt turbo-generators running at 1500 r.p.m. There was also a cross-compound engine-driven unit, the generator having the same phase, cycles and voltage as the turbine generators. Beside this equipment and the motor- and engine-driven exciter units, there were two 225-hp. motor-generator sets delivering alternating current, Fig. 1. M. J. Gross, the engineer of the plant, told us that the electrical energy was transmitted to eight substations and then transformed to 550 volts direct current for use in the mines. Steam for the plant was generated by twelve 250-hp. water-tube boilers equipped with mechanical stokers.

Here was a plant as uptodate as the one we had visited the day before. That both were owned by the one company was a striking indication to me that the central station did not cut much ice with these operators; that they found it economical to generate their energy on the ground where it was to be used.

"How is it that this company has built such substantial power plants while others appear to have been built apparently for short occupancy?" I asked, at the same time yanking Hunter out of the way of an electric locomotive drawing a train of empty coal cars into the mine

Hunter calmly proceeded to count the cars as they rumbled past—an even hundred, I believe—before he turned to answer my question.

"That is business," said he. "These mines are a long way from a central station in the first place; in the second, it will be a good many years before the mines will be worked out. For these reasons it is advisable to put up a substantial building to house the generating units. If the mines were to give out within the next few years, inexpensive buildings would have been the proper structures to have put up. The machinery, however, should be of the best, for when the present mine workings are abandoned, the machinery can be moved to a new site for further use."

"Well, that's clear enough, but with high-priced machinery the fixed charges will be high, while if the machinery is low in cost they will be correspondingly low."

"Right you are, but don't forget that low-priced machinery makes high operating costs. A cheap engine will generally consume an excessive amount of steam,

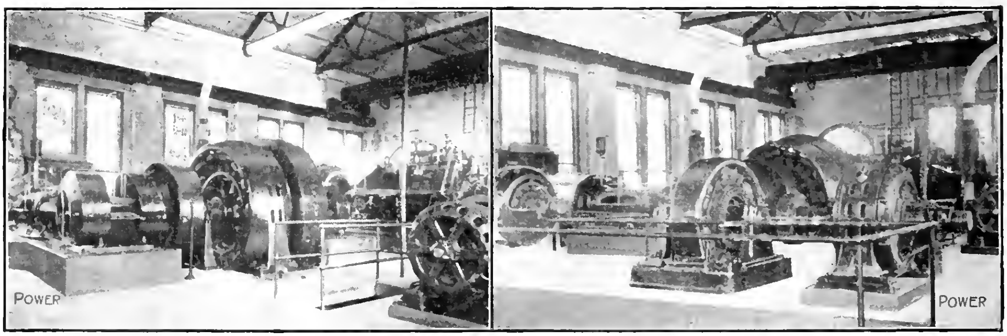


Fig. 1. Power Plant from Which No. 35 Colliery Is Operated

which means that an increased boiler capacity must be had over what would be required with an economical engine plant; this, of course, would lower the saving made on the price of the engine.

"My contention is that cheap machinery means high maintenance costs, let alone the losses occasioned by frequent shut-downs.

"When these units were put in," and Hunter motioned toward the power plant, "they were selected, no doubt, after the question of first cost and operating costs had been considered in conjunction with the load that could be expected during the year. The result was a plant containing expensive machinery and reduced fixed charges, low steam consumption, small repair bills and satisfactory operation. The opposite could be expected with low-grade apparatus."

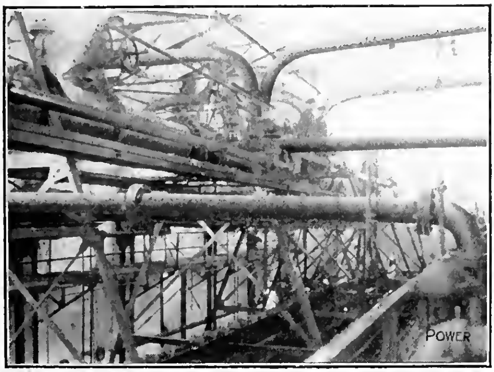


FIG. 2. THE WASTE OF STEAM IN THE AVERAGE MINE PLANT IS DUE LARGELY TO BARE PIPES, LEAKING JOINTS AND WORN ENGINE VALVES AND CYLINDERS

"You would recommend direct-connected units in preference to belted generators, I suppose?"

"I certainly would, because with direct-connected units all troubles from belts slipping, belt repair, etc., are out of the way, less floor area is required, and a smaller building can be used, which means a lower first cost."

"The fact that the general arrangement of the plant is simple, without any attempt at frills, should help with the first cost and with that of maintenance."

"Now you're talking! While simplicity does not mean cutting out necessary apparatus, there is no sense in putting in lines of piping to provide for a breakdown that in practice seldom comes. A steam plant should be designed to avoid as much as possible all chances of breakdowns, and, therefore, the best of material should be used at all points, for one breakdown caused by faulty material will offset the cost of the best many times over. Did you notice how the coal is delivered to the boilers?"

I confessed I had not.

"I'm surprised, because the delivery of coal to a boiler plant is of importance. This arrangement here is about as simple as it can be. Coal fresh from the mine is taken to the boiler house in the mine cars and, after passing through a coal crusher, is delivered to the coal bin above the stoking aisle in the boiler house. Of course, this is an exception, because but few steam plants are situated to take advantage of a drift or a slope level with the boiler-house coal bunkers."

"When you speak of simplicity of design don't you favor cross-connections, so that where several engines have their batteries of boilers they can be arranged to operate with another battery?"

"Now, don't make a mistake; I haven't said any such thing. In fact, interconnections between boilers and engines should be so arranged that any boiler or set of boilers can be used with any engine. The idea is that this arrangement gives the engineer an opportunity to make repairs to any set of engines or boilers without interfering with those in operation.

"With some arrangements of pipe lines there is no certainty that a supply of steam will be had for the fan engines, pumps and hoisting engines in case a boiler tube should burst. One safeguard against the stoppage of the steam supply is to equip each boiler with a nonreturn valve. Then if a tube does fail, putting one boiler out of service, the others will supply enough steam to operate the mine. If an accident serious enough to wreck the boiler plant occurs, then the best protected piping would be of no avail."

"I'll tell you, Hunter, I think the piping between the boilers and engines should be short, and provision made to take care of expansion in all high-pressure steam lines. For the life of me, I can't see how many steam lines could be any shorter than they are, although they may be several hundreds of feet long."

"Unless the mine is equipped with electric drive there is no way to get rid of long pipe lines, and unless properly drained there will be trouble when the water reaches the engines in large quantities, as there is danger of its doing, and wrecking the engine. On the other hand, if the water of condensation gets back into the main line there is danger of bursting the fittings by water-hammer. Not only should the pipe lines be drained, but the valves should be placed so that there will be no pockets of water when the valve is closed."

"The idea is that the pocket of water would go to the engine in a slug when the valve was opened?"

"You've hit it exactly! It is easy to collect such water in traps and return it to the boilers."

During the conversation we had made our way toward a fan house in which was a motor-driven fan. The absence of leaky pipe joints, piston packing and pounding engine was noticeable. Furthermore, the room was clean and free from the mass of grease and general filth so often found.

"This is a good object lesson in favor of electric drive," observed Hunter; "everything neat and clean, no vibrating steam pipes and other annoyances."

"Some steam lines do vibrate; how would you prevent it?"

"Putting in a receiver near the fan engine will frequently stop vibration if the receiver is of sufficient size to supply the engine with steam without materially lowering the pressure in the receiver. This would allow of a practically continuous flow of steam to the engine from the boiler and relieve the pipe of pulsation.

"The waste of steam about the average mine power plant is frightful, due to bare pipes (Fig. 2), leaking valves and worn cylinders. When there are apparently not enough boilers, more are put in; this is generally a waste of time and money. It would be more to the point to put all the engines and pumps in first-class condition, thus consuming a minimum of steam. Then the existing boiler plant would be sufficient for, if not in excess of, the steaming capacity required."

"You don't seem to have a high opinion of the steam equipment of some mines," I remarked as we left the fan house and started toward the street-car tracks in the town.

"Do you know that there are pumps operating in mines on a 24-hr. run which have been in use thirty or forty years and consuming—well, I wouldn't want to say right out, but 160 lb. of steam per water-horsepower would not be too high a figure.

"What can be expected when a pump is operated for long periods and not shut down until something happens? When repairs are being made, nobody thinks of making the pump run more economically; the one idea is to get it back in service as soon as possible, and but little attention is given to the condition of the cylinders, pistons, valves, etc. It's no wonder that steam is wasted.

"The same neglect is found with fan engines. They run day and night, seven days a week, and there is but little opportunity to overhaul them. I have known of fan engines that used about 80 lb. of steam per indicated horsepower-hour when half of that amount would have been excessive.

"The great trouble is that many mine operators conduct their business with the idea of getting a maximum coal output and pay little, if any, attention to the machinery that makes this output possible."

That afternoon we packed our grips and made for Pottstown, where, we were informed, there were several interesting collieries.

The Diesel Principle Applied to Small Engines

SYNOPSIS—This engine, of German design, is of the high-compression, double-piston type and embodies simplicity as well as compactness. With a direct-connected generator it is made in sizes of 10 to 40 kw.

A successful attempt to adapt the Diesel principle to the small oil engine has been made by the Allgemeine Elektricitäts Gesellschaft, of Berlin, which is now putting out direct-connected generating sets, in the two-cylinder model, with capacities of 10 to 40 kw. The engine is of the double-piston, two-cycle type, employing 420- to 570-lb. compression and a fuel-injection pressure of approximately 850 lb. In order to insure reliability in the hands of unskilled attendants, simplicity, accessibility and interchangeability of parts have been made an important feature in the design, and compactness is further increased by having the end of the crank case terminate in a flange to which is connected the stator of the generator.

Referring to Fig. 7, the compressor is seen to be mounted in line with the working cylinders and is driven from the main crankshaft. It comprises a two-stage injection pump E and a scavenging pump P. The latter is double-acting and is regulated by a rotary slide valve mounted on the vertical intermediate shaft. The upper part of the crank case forms a scavenging air reservoir L, into which project the lower ends of the cylinders. These are provided with scavenging ports, so that the air follows the most direct path. The relative locations of the pump P and the reservoir L do away with the necessity for intermediate piping. The injection pump is fitted with ring plate valves.

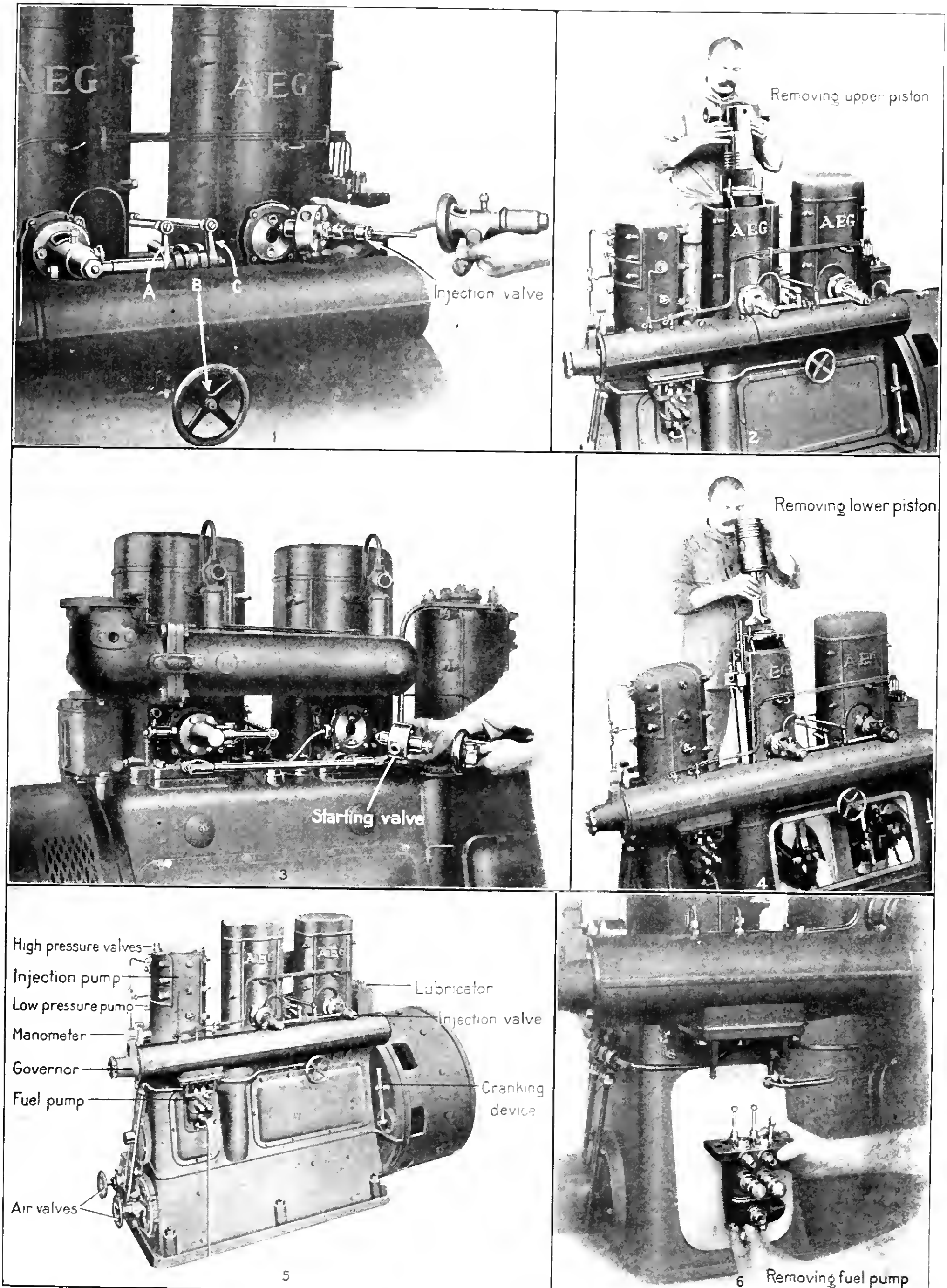
The air for starting and for fuel injection is stored in the cylinder F, located with the lubricating receptacles S in the under-frame of the engine. This not only provides a more convenient arrangement, but also allows the numerous valves for starting and fuel injection to be replaced by a common distributor, which carries a manometer (see Fig. 5) and a safety valve.

Amply dimensioned hand openings are provided, permitting convenient inspection and removal of parts. The driving gear is provided with forced lubrication, the oil being led to the bearings through passages in the casting and then distributed through recesses in the crankshaft to the pivots of the connecting-rods and the suspension rods, finally rising further through pipes to the piston pins. Nonreturn valves prevent the oil from running into the pipes when the engine is at rest, and a hand pump permits the pipes to be filled or washed out while the engine is idle. In the larger sizes the pistons are oil cooled. In this case the oil, which is supplied by a gear pump, flows to the lower pistons through jointed pipes and to the upper pistons through conical pipes, finally discharging through funnels.

A special point has been made of rendering the piston easily demountable. In about 10 minutes after stopping, the upper piston can be removed, and in another 10 minutes the lower piston can be taken out. These operations are shown in Figs. 2 and 4. There are no pipes to be disconnected, no valves to be removed, and no covers, tightened by packing, to be unbolted.

The crankshaft is driven by worm gearing through a vertical intermediate shaft, which can be removed bodily with the bearings and wheels after loosening a few bolts. The governor, mounted at the front end of the camshaft, works directly onto the fuel pump by means of an adjusting rod sliding in a slot on the camshaft. This does away with any external lever transmission. The handwheel shown is for adjusting the speed, which can be read from a tachometer placed above it.

Some difficulty was experienced in designing the fuel pump for the small engine, especially in connection with the regulation of the quantity of fuel, which in many cases amounts to only a few drops. As the same amount of work is done in one cylinder of the new engine as in two cylinders of the single-piston type, however, the quantity of fuel per cylinder is doubled, and its regulation is thus simplified. It is effected by the movement of a cam acting on the suction valve. The starting valves are controlled mechanically by means of cams from the



Figs. 1 to 6. Showing Engine and Generator Complete and the Ease with Which Parts May Be Removed camshaft. The driving lever *A* (Fig. 1) for the starting valves and the lever for the injection valve are arranged eccentrically, so as to bring them into operation alternately by switching over a lever. For starting, therefore, it suffices to open the air admission by means of the handwheel *B*, and to throw over the hand lever. These starting valves are accessible and can be exchanged in a few minutes. The injection valves for admitting the fuel into the working cylinder are placed opposite the starting valves, and the needle is likewise moved by means of a disk from the same camshaft. If it should prove necessary to repack an injection-valve needle, the entire

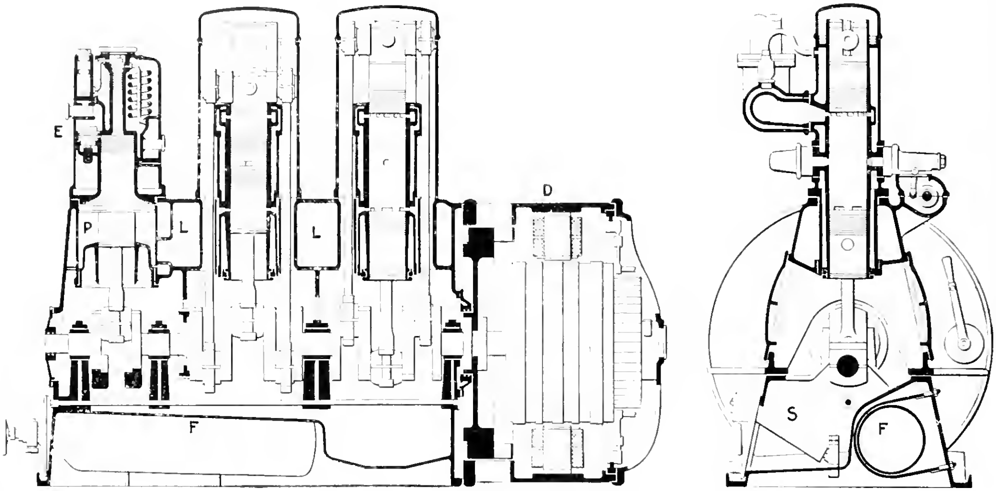


Fig. 7. Longitudinal and End Sections through Engine

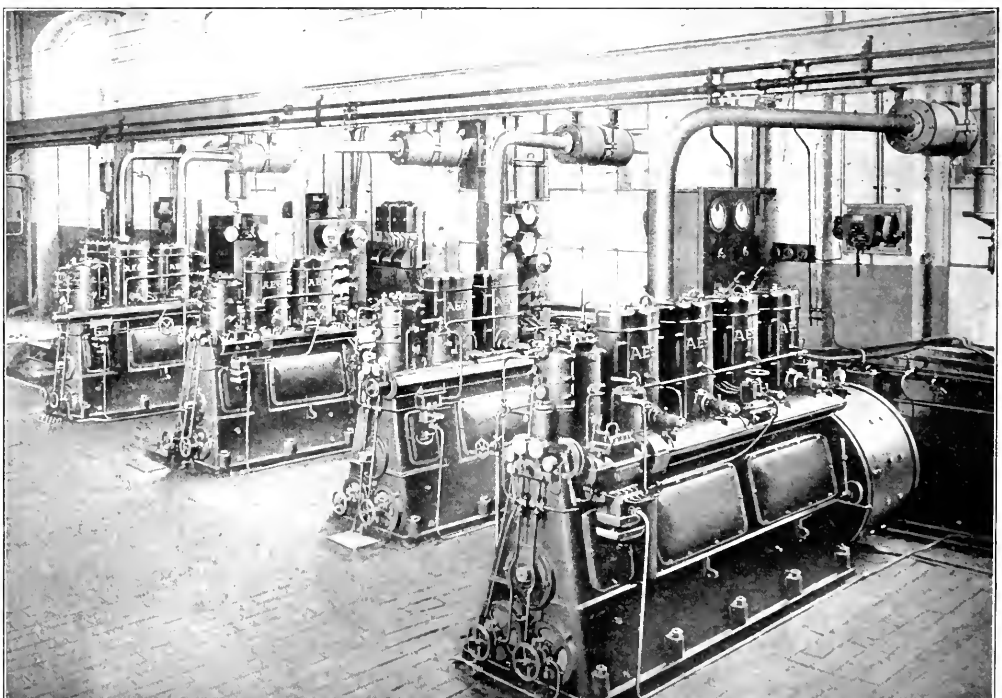


Fig. 8. Engines Set Up for Testing at A. E. G. Works

valve can be taken out after the engine has been shut down, and a spare one put in its place; this takes about 15 min. The adjustment of the play between the cams and camshaft and the roller of the driving lever, and therefore the exact timing for the opening of the needle, is carried out by means of calibrated disks placed beneath the needle.

These engines are built for a speed of 500 r.p.m., at which they develop their normal output.

Coal, the Big Item

The largest single item in the operating costs of any steam power plant is coal. In most plants the purchase of coal is a matter of careful consideration, and in the larger ones it is usually bought under specifications. Once the coal is in the bunkers, this careful consideration stops and the actual burning of the coal is very rarely given more than a passing thought, as long as the steam pressure is kept up. Of course, there are some plants where this does not apply, but in the majority it does.

The men employed are paid the lowest possible living wage and are chosen more on the basis of the wages they will work for than the results they are able to produce. The man who burns the coal can easily vary the efficiency of the boiler by 10 to 15 per cent., or the heat absorbed by 15 to 20 per cent., yet he is at the bottom of the payroll.

No revolutionary advancement has been made in power plants recently, and the increased efficiency is accomplished only by taking each process separately and bringing it up to the highest standard. It would therefore seem wise, in attempting to increase the overall efficiency of a plant, to start with the item that represents the largest expenditure and work down the list.

In office-building plants the cost of coal represents some 35 to 40 per cent. of the total expenses and boiler-room labor 12 to 15 per cent. In big plants the cost of coal is 50 to 55 per cent. and the boiler-room labor 7 to 8 per cent. Take a concrete case of a certain office building in New York City that employs two firemen at $600 a year each. Their coal costs approximately $10,000 a year. If we assume that the boiler efficiency is 60 per cent., and that by paying $900 a year men could be obtained who would operate the boilers at an efficiency of 70 per cent., it would be a paying investment. The increase in wages is $600 a year. The increase in boiler efficiency amounts to a reduction in coal burned of 14.3 per cent., or $1430. The net result is $830 to the good by the change—not a matter of philanthropy.

Any plant owner can figure out for himself what a small increase in the boiler efficiency will amount to in dollars and cents, and may find it profitable. The efficiency of the boilers may be increased in several ways, but first, proper equipment must be furnished. Every boiler plant should be equipped with a draft gage, stack thermometer and means for determining the CO_2. The cost of this whole equipment need not exceed $100, which would be repaid in a very short time.

Then the firemen should be taught the use of this apparatus to determine the proper method of handling the fires to secure the highest efficiency. A bonus system for savings over a certain amount would probably be productive of the best results. If the firemen are able to save the plant money by their efforts, they should logically be entitled to a part of it.

Dayton Power Pump

The Dayton Pump & Manufacturing Co., of Dayton, Ohio, is placing on the market a new power-driven

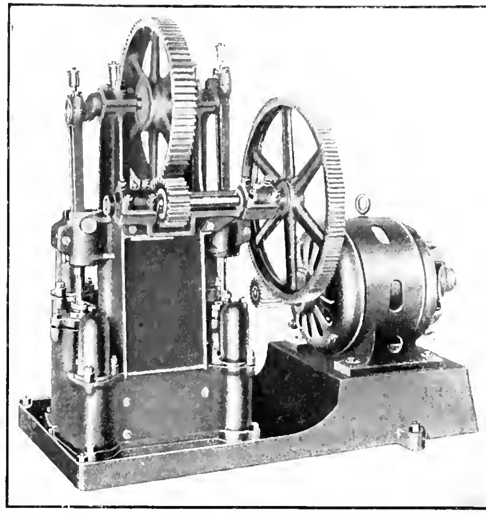


Fig. 1. Motor-Driven Duplex Double-Acting Pump

pump, Fig. 1, of the duplex double-acting type. Being double acting on both sides, four impulses are imparted for every revolution of the cranks, and a steady stream

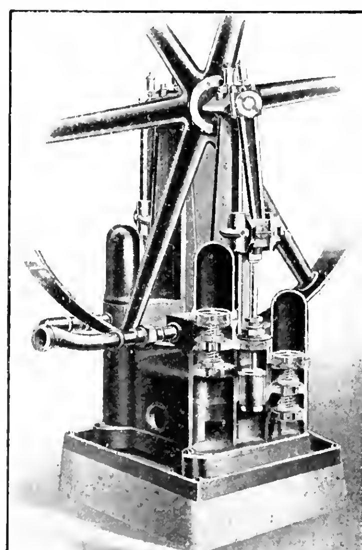


Fig. 2. View Exposing Valve and Pulsation Chambers

is discharged. The cranks are set at 90 deg., so that when one piston is moving at its highest speed and delivering its greatest amount of water, the other piston is moving at its lowest speed and delivering a proportionately smaller amount of water. In this way the flow and torque are equalized, so that a minimum expenditure of power per cubic foot of displacement results.

An unusual feature is an air chamber over each valve chamber, and in addition, a large air chamber forms part of the body of the pump immediately under the gears. As a result of these five chambers there is no perceptible wave line to the discharge, which is practically as steady as the outflow from a centrifugal pump. The arrangement of plunger and valves is shown in Fig. 2, a sectional view of the pulley-driven pump. The new motor-driven pump is made for pressures up to 100 lb. and is designed primarily for house service.

Chimneys for Havana, Cuba, Power Plant

The accompanying illustration shows the five chimneys constructed by the Weber Chimney Co. for the Havana Railway, Light & Power Co., Havana, Cuba.

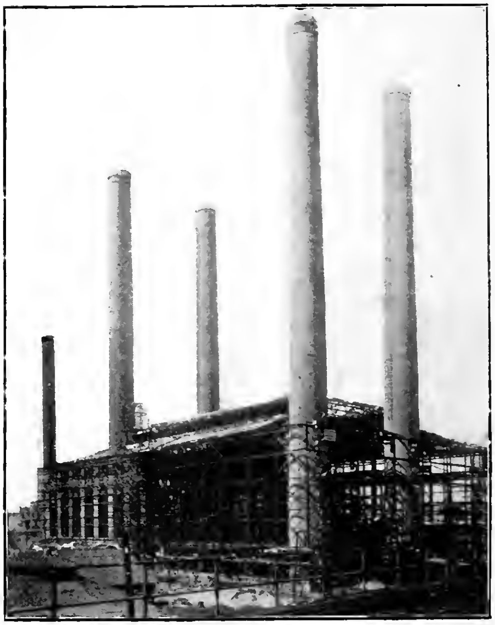
In 1910 the company built a cylindrical chimney 200 ft. high by 10 ft. diameter, of reinforced concrete. After it had been in use approximately three years, a consolidation of the Havana Railway, Light & Power Co. and the Havana Gas Co. necessitated the construction of a large central station, which was started early in 1913. An order was placed for four coniform reinforced-concrete chimneys, each 275 ft. high and 14 ft. inside diameter at the top. Six months from the date of starting work these were completed.

The chimneys rest on individual foundations 32 ft. square and 6 ft. 6 in. thick, supported by piles. In the lower part of the foundation are four layers of steel. The bottom layers run diagonally to the sides and consist of ¾-in. round bars at 8-in. centers; the two upper layers are placed from 4 to 6 in. above the diagonal net and about 8 in. from the bottom of the foundation, and run parallel to the sides. The vertical bars in the shaft run into, and anchor beneath, the horizontal steel reinforcement in the foundation, providing anchorage for the chimney shaft.

The outside diameter at the base of the shaft of each chimney is 20 ft. 6½ in., tapering to an outside diameter of 15 ft. at the top. The wall thickness of the shaft at the foundation is 19 in., tapering to 6 in. at the top. There are two hundred ¾-in. round vertical bars in the shaft, extending to a height of 22 ft. above the top of the foundation, where the number is reduced to 132 for the next 20-ft. section, decreasing uniformly to the top, where there are sixteen ⅝-in. round vertical bars in the upper 30 ft. of the chimneys. The smoke openings (7 ft. 2 in. wide by 14 ft. 2 in. high) which received the breeching from the boilers are 56 ft. above the foundation and are 20 per cent. larger than the area of the chimney at the top. There are two opposite openings in each chimney, and a baffle wall is built in the center of the chimney, starting 2 ft. below the bottom of the openings and extending to a point 3 ft. above the top.

There is a reinforced-concrete lining 58 ft. 6 in. high, starting at a point 4 ft. below the opening. The lining is reinforced vertically and horizontally by sixteen ½-in. round vertical bars, evenly spaced, and by horizontal rings at 14-in. centers encircling the vertical members; these take up the shearing stresses caused by the wind and temperature. The lining is carried on a corbel supported by the outer wall of the chimney. All vertical steel in the shaft is calculated to take up stresses produced by a wind velocity of 100 miles per hour.

The chimneys are inside of the power house, and in order to utilize the space two storage rooms were provided in each. A floor was placed at an elevation of 18 ft. above the foundation, and an opening provided so that this part of the chimney is accessible. At 36 ft. above the



Reinforced-Concrete Chimneys for the Havana Power Plant

foundation is another floor and storage room. A ladder is provided on each chimney, running from the top of the chimney to the roof of the building.

The present boiler installation consists of 24 water-tube boilers, rated at 650 hp. each, a total of 15,600 hp.; provision has been made for eight additional stoker-fired boilers. Three turbine generators of 10,000 kw. are operating at present, with provision for an additional unit.

The Action of Ice and Common Salt (sodium chloride) is to lower the mixture temperature below 32 deg. The depression of temperature depends mainly on the proportion of salt used, and partly on the rate at which heat is supplied from the outside. The following table gives the approximate temperatures resulting from the use of different proportions of salt and ice:

Per Cent. of Salt in Mixture	Temp. of Mixture, Deg. F.
5	26.6
10	19.9
15	11.8
20	1.6

The minimum temperature obtainable with ice and salt is about —7.5 deg. F., this temperature being given by a 24 per cent. mixture.

Editorials

Fuel Economics

The slogan, "Made in America," is aimed to incite domestic industries and manufactures. As a result many new factories will be built in the near future and probably many old plants will be remodeled to meet increased demands and manufacture new lines. All of these factories will require power, which will benefit the central stations and also be the occasion for many new isolated plants—some large and some small. To manufacture economically, cheap power will be required, will be absolutely necessary, and though the "Made in America" indorsement may secure many sales at this time, when serious foreign competition is not felt, the time will come when only the American producer who is manufacturing economically and efficiently will be able to hold his own.

Even in an efficiently operated plant, from twelve and one-half to fifty per cent. of the cost of power is found in the coal bill, the large power house operating on the lower unit cost. Coal bills must then be kept down, and to do this only the economical coal must be burned, the coal that will evaporate the most water for a given outlay. This does not mean the best coal procurable nor yet the cheapest; it means the most economical, for efficiency in combustion is almost entirely a matter of correct grate and combustion-chamber design and care in firing, conditions that may be relatively realized with the same results when using a low-grade coal as when using the more easily consumed coals of high heating value.

The price of coal varies to a great extent in different localities, and coals vary among themselves in heating value and in ash and refuse contents. The heat units in the coal increase its value but not proportionately, for the ash and refuse contents not only add expense by entailing definite outlays for their disposal, but also have the tendency to reduce boiler efficiencies. Of two grades of coal of equal heating value, the one with the lower proportion of ash and refuse will develop the greater boiler efficiency—grates and combustion chambers being equally well proportioned for their respective grades of coal and equally good attention paid to the firing of the boiler. The detracting effect of increased ash and refuse contents of a coal is not as great ordinarily as the beneficial effect of an increase in heating value of the fuel, the diluents forming but a comparatively small proportion of the coal, unless it happens to be a very inferior grade. Heat units per pound generally govern the price of the coal, but the price in no way fixes its true economic value, for the increase in cost of high-grade coals is much more rapid than the increase in their heating value.

As a general rule, where coal is relatively cheap—near the source of supply, for instance—more heat units are purchased for the dollar when buying a low-grade coal. Where coals are expensive, on the other hand, the heat units sold for a dollar are more nearly the same for coals of various grades, as in such localities the coal has to carry a burden of freight and delivery charges that are not proportioned to its heating value but are unduly severe on the poorer coals, notwithstanding that freight rates are usually somewhat lower on poor fuels. Where coals are cheap, the most economical grade to use is the poorest grade that can be efficiently burned on properly proportioned grates, etc.; while in sections of the country where coals command high prices, better grades can be economically used.

With the constantly increasing price of coals, one other general rule tends toward economical choice of fuel for an efficient power house, which is that in cases where two grades of coal do not vary greatly in economic value—fuel cost per boiler horsepower—it is usually advisable to adopt the poorer grade even when the net fuel cost is slightly greater than that of the higher-grade coal. The fuel cost of the more economical and higher-grade coal increases more rapidly for an increase in tonnage cost of fuel than is true in the case of the poorer coal, so that only a little of the inevitable increase in the price of all coals will throw the economic balance in favor of the inferior coal and any further general increase in cost of coals will steadily increase the relative economy of the fuel of less heating value—the saving increasing progressively.

The Archaic Boiler Horsepower

We are glad to see our friends of *The Locomotive* place the stamp of disapproval on the horsepower as a unit of boiler capacity (see page 175). In 1876 a committee of eminent engineers appointed to conduct a competitive test of the boilers at the Centennial Exposition decided upon the rate of evaporation of 30 pounds per hour from feed water of 100 degrees Fahrenheit and at 70 pounds gage pressure (barometer unknown) as equivalent to one horsepower, this being considered about the rate at which a boiler would have to steam per horsepower developed by the average engine of that time, under average conditions.

At the time and at the best it was only the crudest kind of an attempt to correlate the capacity of the boiler and that of the engine, for there were then many engines which required less than 30 pounds of steam per hour per horsepower. Today, with boilers evaporating two or four times as much water per square foot of heating surface and engines requiring only one-half as much steam per horsepower, there is a wide and variable discrepancy between the horsepower of the boiler as determined by the Centennial standard and that of the engine or turbine which it can supply with steam.

How should boilers be bought, sold, and classified—by the amount of steam which they can make per unit of time, or by the number of square feet of heating surface which they contain, or how? The horsepower rating is supposed to be a statement of the rate at which the boiler can make steam, but is in the awkward unit of 34.5 pounds per hour at the standard condition of "from and at 212 degrees." If one wants a boiler which will make the equivalent of 3000 pounds of steam per hour from and at 212 degrees, he says: "3000 ÷ 34.5 = 90, about. Give me a 100-horsepower boiler."

And then the boiler maker says: "Ten square feet per horsepower—give him 1000 square feet of heating surface." So the thing gets down to a heating-surface basis after all, notwithstanding the fact that the evaporation per square foot of heating surface may vary from 2 to 10 pounds, according to the amount of grate surface supplied with it and the rate at which the coal is burned.

Another basis for rating is the amount of heat which the boiler can absorb per hour. To evaporate 34.5 pounds of water from and at 212 degrees requires 34.5 × 970.4 = 33,478.8 B.t.u. A kilowatt is equivalent to, say 3415 such units per hour. Messrs. H. G. Stott and Haylett O'Neill suggest that the capacity to absorb 34,150 B.t.u. per hour be taken as the unit of boiler capacity, and that this unit be called a "myriawatt," signifying 10,000 watts.

We do not see that this improves matters much. There is no such definite relation between the kilowatt and the number of pounds of steam that it takes to make one, as to warrant the use of an awkward five-place divisor, and it simply means tricking out the old boiler-horsepower in a new regalia of metric trappings and continuing it upon the stage.

Should we "get the hook" for it? If so, when we are describing a plant with four 300-horsepower boilers, shall we say "four boilers of 3000 square feet of heating surface each," "four boilers capable of evaporating 9000 pounds of water per hour each"—or what?

The Practical Man's Boiler Test

Two methods of conducting boiler tests are now generally accepted—one according to the short code of the A. S. M. E. and the other based on the more elaborate standard code. The first contains about forty items, readings or calculations for which are necessary, and the complete code contains over one hundred. Condensed and standardized as are the calculations and complete as is the information gained by following these codes, a boiler test is not simple, but requires considerable preparation and care and consumes much time. Furthermore, when accomplished, the test is rarely typical of actual operating conditions. As a means of establishing a record, or standard, to be striven for by the operating force it is exceedingly valuable, but as a reliable record of efficiency of average operation and a true gage of the economy of the plant, it leaves much to be desired. What is required is a continuous record to show the true efficiency of the plant at all times, a "practical man's boiler test," and a test that the boiler operators can easily comprehend—a test with the results continually before the fireman.

It is neither fair to the boiler-room force nor conducive to the best results to blame it for wastes after they have occurred—especially after they have been going on for some time. The time to call attention to them is while they are occurring. The boilermen should know the instant that the boilers commence falling below requirements, and this can be realized only when simple and continuous records are provided for their frequent inspection.

The apparatus required is neither very complicated nor complex. All that is needed are some automatic device for recording the amount of water fed to the boiler and means of weighing the coal as fired. Automatic firing simplifies the keeping of records of fuel consumed, but even when hand firing is employed, satisfactory records can be kept by weighing the fuel—practice will soon enable a competent fireman to accurately gage his fuel consumption in reference to his boiler feed. Pounds of water evaporated per pound of fuel is all that really matters, and the greater this ratio the better the boiler efficiency. Automatically recording pyrometers, CO_2 recorders and temperature records of feed, etc., all assist in discovering the reasons for falling off of boiler efficiency, but the vital records are those of fuel consumed and water evaporated while maintaining steam pressure.

Careful boiler tests should be made from time to time, but more to fix the standard of operation for the boilermen than for any other reason. The "practical man's boiler test" should be a continuous operation in any boiler plant making claim to efficient operation. It alone can lead to economic operation, it alone is fair to the boilerman, and it alone shows whether the fires are kept in good condition and how carefully and systematically the heating surfaces are freed from soot, etc.

The Loafing (?) Engineer

When we say "loafing," we have in mind the man whom the employer generally finds sitting in the old easy-chair reading a technical or trade journal or just smoking his pipe. Of course, everything is clean about the plant and the machinery is running smoothly, but there can sometimes be detected in the employer's face a look of dissatisfaction. He is paying his engineer a good salary and cannot see that the latter is doing any work and seems to think that he is not getting value received for his money, for a cheaper man could hold down the "Old Armchair" just as well.

This is a view taken by a great many employers and is altogether wrong. The very fact that the engineer finds time to "loaf" and that the owner is not annoyed by frequent shutdowns should be sufficient to convince him that the engineer is a good man and has his department in perfect order. Look out for the engineer that is constantly rushing wildly about with greasy clothes and smutty face and a handful of tools, for unless his plant is dying of old age, there is something wrong with the man.

The employer who wants a man to build boxes, mow the lawn, look after the roofs and a few other "little things" to keep busy, is not looking for an engineer and will seldom get one, and when something unforeseen and real annoying, like a wrecked engine or bagged boilers, happens, he generally gets about as much sympathy as he deserves.

"Some Original Ideas"

When we called for accounts of stupidity, in our issue before the last, under the heading, "Just for Fun," we started something, for we have had a deluge of them. Evidently, nearly everyone has a stock of such stories up his sleeve. We can use but a few of the best, as we said, but if our readers do not mind sending them in, in spite of a long chance that they may not be printed, we do not mind reading them over to see if they are available.

Correspondence

Live-Steam Ash Ejector

In the issue of Dec. 22, page 889, E. H. Clark asks what the trouble is with the ash ejector. I believe if he will increase his steam line to 1½ or 2 in., and then, instead of a bell nozzle, use a throttling nozzle having a diameter not over ⅝ in., he will have no further trouble with the construction as shown in the illustration referred to.

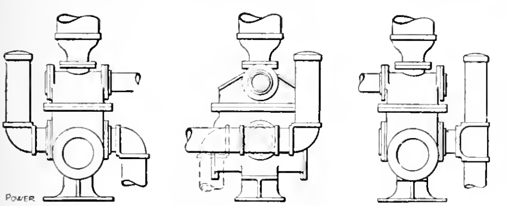
The nozzle should be about even with the back edge of the hopper opening. The ejector will probably work a little better if the end of the 6-in. pipe is left open where the live-steam pipe enters. If closed at all, the area should equal an opening 3½ or 4 in. diameter.

F. F. JORGENSON.

Gillespie, Ill.

Pumping Hot Water

It is surprising how many have trouble when trying to pump water at 210 deg. F. or over. To do this successfully, the pump should be able to deliver the maximum quantity of water at slow speed and the water-supply should be at least 30 in. over the discharge valves, for the reason that if a vacuum is created in the suction pipe, some of the water will flash into steam and fill the water cylinder with vapor. Although it takes 212 deg. F. to boil water under atmospheric pressure, or 14.7 pounds, in a vacuum it will boil at a much lower temperature.



FORMS OF AIR CHAMBERS FOR SUCTION PIPES

It is a good idea to place an air chamber in the suction pipe, as shown in the illustration. The discharge air chamber should be kept three-quarters filled with air; a glass gage will show the water level at a glance. Should the air get away, the chamber can be recharged by admitting air into the suction line.

A sight-feed lubricator should be connected to the steam pipe above the throttle valve, but a mechanical lubricator may be connected below the throttle valve if desired. If an automatic governor valve is used it should be placed above the throttle valve, but a chronometer governor valve should be placed below the throttle and the oil should pass through them in either case.

It pays to use good packing, which should be soaked in warm water before being put in the piston: the joints should not be in line or the packing follower-bound. It is unnecessary to subject the rod packing to great pressure; it is better to repack than to continue to tighten the gland. It will be found with these precautions that hot water is no more difficult to pump than cold.

THOMAS J. ROGERS.

Jersey City, N. J.

Proper Location of Overflow

In a vacuum steam-heating system that requires no jet water at the vacuum pump, the air-separating tank should not be equipped with such auxiliary appliances as a float-controlled inlet and outlet valve, gage-glass, overflow pipe and handhole. A large tank, with these appliances, is necessary only where jet water is used, because the operator may use more jet water than is required for boiler feed, causing it to flow through the heater into the sewer. This would tax the heater beyond its proper capacity and reduce the temperature of the boiler feed. Therefore, an automatic valve is placed between the tank and heater, so that the tank will overflow to the sewer and not flood the heater when excessive jet water is used.

T. W. REYNOLDS.

New York City.

Concrete as a Furnace Lining*

Our experience with concrete as a furnace lining with underfeed stokers was not satisfactory. The concrete was made of cement and gravel which ranged in size from sharp sand to pebbles the size of a hen's egg in proportions of about 1 : 4. The old firebrick side walls were taken out, the walls cleaned and thoroughly wet, the concrete was poured in place in forms, in the usual manner, and allowed to dry several weeks before the boiler was put into service. As a means of comparison, another furnace was relined with firebrick at the same time. These furnaces are subjected to hard service, and the clinkers stick to the side walls so that it is necessary to use a sledge and chisel bar to remove them, and more damage is done in this way than by the fire. The concrete walls did not stand as well as the firebrick and the clinkers gave about the same amount of trouble.

Concrete has one important advantage, however, in that it is less expensive to put in, but even if allowed to become thoroughly dry, and heated up slowly, it will give some trouble from cracking and falling out, although this may be prevented by reinforcing it with expanded metal or rods. In our case it was tied in one place only, and perhaps more experience would have produced better results. Oyster shells used as a flux prevented clinkers sticking to the walls to a great extent. Two or three scoops of these shells were thrown in next to the walls on each side after cleaning the fire. I believe that it was the lime in these shells that did the work, and crushed limestone would probably do the same.

*See also page 840, Dec. 15, 1914; page 62, Jan. 12, 1915, and page 131, Jan. 26, 1915.

I find that there is a great difference in firebrick and fireclay, and also in the workmen that build the walls. It is customary in our plant to have this work done by contract, with a guarantee that the work will last one year. One contractor had to rebuild his walls twice during the year, and another put in a wall that was not tied to the outside wall, and it fell out in less than a month. A third put in a wall that did not require any repairs during the year. Good material should be used, and it is essential that it be tied solidly to the outer wall at every fifth course by a header tied into the outside wall, and if subjected to hard usage the headers should be placed every third or fourth course. The fireclay should be made very thin and the least possible amount used. The brick should be dipped in it and rubbed to a tight fit to make a firm bed, so that there is no chance for the mortar to chink out and let the brick fall down. In arches the proper wedge and skew brick should be used to get the proper arc with a full bearing the entire length of the brick without resorting to fireclay to do it.

J. C. HAWKINS.

Hyattsville, Md.

Safety in Handling Refrigerants

An editorial in the Dec. 15 issue comments on New York City's refrigerant regulations. The regulations appear in the same issue as does comment on them by members of the American Society of Refrigerating Engineers.

There should be, as the editorial points out, widely adopted rules for the safe operation of refrigeration machines, as there are for boilers and steam-driven machinery. In this city (Chicago) the laws governing steam apparatus are strict, but nothing is said of high-pressure gases or air.

As the water here is exceptionally good for making raw water ice, there are many motor-driven ice machines, and some of them are operated by men who are not licensed engineers. For the heating system in such plants low-pressure steam or hot water can be used, so that the board of examining engineers has as yet nothing to do with them. Surely there is danger in these motor-driven ice plants even though there are no high-pressure steam boilers. Such plants are often located in thickly settled residential neighborhoods, close to schools and churches.

The license law should cover all apparatus carrying pressure, whether steam, gas or air. Regular inspection should be made and none but competent men allowed to operate. There is without doubt less chance of dangerously high condenser pressure with a motor-driven unit than with steam drive. Increased pressure will cause the circuit-breaker to trip or a fuse to blow, whereas a steam engine will keep going until something gives way. But again, circuit-breakers may be tampered with or even blocked in and heavy fuses used by some who do not realize the danger.

Pop safety valves are good in some ways, but sometimes they are both a nuisance and a danger. It is, as Mr. Fairbanks remarked (Dec. 15 issue, p. 866), almost impossible to get an ammonia safety valve that does not leak. When once it opens it seldom seats tight again until it has been taken apart and cleaned of the grayish powdery sediment which has collected. Rather than shut a compressor down in a rush season, many engineers will plug the valve so as not to lose the ammonia.

If the outlet of the safety valve is piped into the suction side of the compressor, it might leak a little all the time and so cut down the efficiency of the machine. Again, if the outlet is piped into water or to a high point above the building, there can easily be a constant loss of ammonia. In one plant the safety-valve outlets of a number of ammonia compressors were piped into a header, and this extended high above the building. The continual loss of ammonia was finally traced to this manner of connection, and the header was done away with and the valves allowed to discharge into the engine room. This often proved a source of annoyance when starting up a compressor which had been down so long that liquid had collected in the discharge line. The valves nearly always opened until the discharge line had become cleared of liquid. In the case of a large direct-expansion system, when a small slug of liquid was pulled into the compressors the valves would often open. In another plant two different suction pressures were carried on several compressors. When one compressor could be spared from the high back pressure, it would be changed over to the low, and often while this change was being made there was loss of ammonia and inconvenience to the men owing to the pop valves opening.

In the foregoing cases the safety valves were a nuisance and were really not necessary. Whether or not a pop valve is the proper thing on an ammonia compressor is a question hard to decide. These valves will relieve a compressor or condenser of over-pressure, it is true, but most engineers will know of the increasing pressure without having the engine room filled with suffocating gas or losing much ammonia. The sound of the machine, whether motor or steam driven, will be warning enough to any competent man. An engineer should be near enough to hear his machinery, or if he should have to go away he should have a man in the engine room who knows enough to shut down in case of accident.

There are not many things liable to happen that will cause a sudden rise in the condenser pressure. Shutting off the water from the ammonia condenser will not cause so sudden an increase of pressure that there is not plenty of time to slow down or stop the compressor.

Any cross-connection between a hot and cold water-supply should not be allowed on pumps supplying a condenser with water. Such a connection can and has caused trouble, but with proper inspectors such cases would be few. Another cause could be the breaking of the suction line. This would allow the compressor to draw in much air, but with an operator within hearing distance he would have plenty of time to shut down. One other cause of dangerous pressure—and in this case I do not believe a safety valve would do much good—is the sudden closing of a valve on the discharge line between the compressor and condenser. This can hardly happen unless an angle or globe valve had been put in the discharge line with the pressure side of the disk toward the condenser. In that case the disk might come off and suddenly close the discharge; the shock would rupture something. But as in other cases proper inspection would minimize the chance of such a condition.

If a safety valve opened directly into a small engine room, the charge of ammonia would probably be lost as it would be impossible for a man to shut down the machine unless provided with a helmet. A positive device for shutting down the compressor when the discharge pressure reaches a predetermined point is safer. Such devices are in use in some places and work well. Each has a connection from the discharge line to the engine governor, and when the pressure goes to the point at which this control is set the governor acts and the engine is shut down as if the governor belt broke. Such a device can be tried daily or weekly and kept in proper working condition. A safety valve on an ammonia line or container cannot be tried occasionally like one on a steam boiler, to guard against its sticking when needed.

Proper check valves should be placed in both suction and discharge lines of compressors so that in case of a bursting cylinder the gas will be shut off. It is seldom that a serious accident occurs from over-pressure during the operation of an ammonia compressor. When the pressure gets too high it will blow out a gasket in the system or perhaps split a pipe in the condenser. What really causes serious accidents is the dropping of a broken suction valve into the cylinder or something breaking on the piston which will knock out a compressor head. Fortunately, this does not happen often.

Internal explosion in the discharge receivers and the oil separators occurs from permanent gases or inferior lubricating oil which becomes ignited when a high discharge temperature is maintained. The proper oil and care in keeping noncondensable gases out of the system and a correct discharge temperature will do away with the possibility of such explosions.

It is common practice in most new installations to test the high-pressure side with air at 300 lb. and the low-pressure with 150 lb. air pressure, and once a year in old plants after the winter overhauling. This is particularly dangerous in motor-driven compressors where the speed is constant. The air discharged by the compressor reaches a dangerous temperature when the gases from the oil and ammonia mix with it. As several bad ruptures have resulted from this cause, the use of a small unit built for testing purposes should be insisted on and the temperature of the system kept low to insure safety.

Another noticeable neglect in the ammonia system is the lack of suitable hangers for coils and pipe work. In direct-expansion systems the coils on the walls and ceilings of some rooms become so heavy with frost that the hangers give way and allow the coils to fall and break. This can also happen on suction lines not covered and allowed to accumulate frost. There should be proper means of supporting all coils and lines, and care should be taken for the regular removal of frost.

Electrically operated valves are valuable in most plants. In case of accident the machines could be shut down and the ammonia cut off from a point outside the building by means of switches. Discharging ammonia into water or into the atmosphere in case of accident has its dangers in a large plant unless there is a river or lake nearby. Some other way of disposing of a large charge of ammonia must be found.

The adoption by the City of New York of a set of rules for the safe operation and proper inspection of all machinery handling high pressure should be and most likely will be the beginning of improvements in the ice-machine business. Competent men to operate and inspect the plants would make them safe.

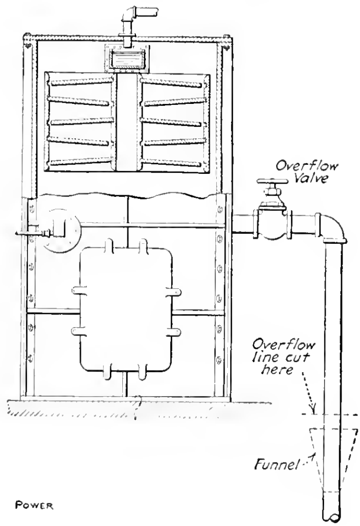
Chicago, Ill. A. G. Solomon.

Saving in the Pump Room

The idea that the greatest possibilities for improvement in economy are to be found in the boiler room seems to be generally accepted. This story, however, is to show that leaks of some magnitude may be found in the pump room.

On taking charge of the plant, the new chief had certain suspicions as to the cause of the low feed-water temperature. As soon as possible he placed a recording thermometer in the feed line. The first chart confirmed his suspicions and an investigation disclosed several interesting items. The feed-water heater was of the open type, to which condensate from various heaters, driers, etc., was returned.

The overflow pipe was connected without an opening and concealed the excessive waste of water. The new chief cut the pipe and put in a funnel (shown by dotted lines in



Overflow Changed

the illustration) and it was observed that for a time a stream of hot water would pour from the overflow—then the makeup valve would open wide. It was evident that water was coming back in slugs, showing that the receiver capacity of the heater was not sufficient for these conditions. Much hot water was being wasted to the sewer at times and a large quantity of cold makeup water was called for at others.

More capacity was at hand in the shape of an old receiver, which had been used up to the time the heater was put in. It was still connected up for an emergency so that it was only necessary to combine the two and maintain a constant level in the heater and waste no hot water through the overflow.

The makeup valve was moved from the heater to the receiver and set to operate only when that vessel was nearly empty. At first it was needed, but now it has almost gone out of use. The main bearings of the big engine were water-cooled. This water had formerly been wasted to the sump pit and then lifted to the drain by an ejector. The chief piped this, together with the jacket water, from the air compressor to the receiver. This nearly equals the amount of makeup water needed.

The average temperature from a week's charts among the first was 140 deg., and from the latest it was 212 deg. These two sets were turned over to the manager, together with a statement of the monthly coal bill. Where the coal formerly cost in excess of $3000, there was now a saving of about $200. As a saving it interested the manager and he actually offered the chief words of praise —but nothing more.

William E. Dixon.

Cambridge, Mass.

Separator Drain as Steam Supply to Pump

I read in Power, Dec. 22, page 890, of using a steam-separator drain as a supply line for a pump. This is very good as regards the engine, but how about the pump?

I think a much better way would be to repair the trap or install one that would work, rather than run this wet steam to the pump, for if only one pump is on the line, and that is shut down while the engine is running, all the condensation must go through the engine. As water is bad for an engine cylinder, as every engineer knows, will it not do damage to the pump also? The pump is one type of engine.

I have seen plants where every precaution was taken to insure dry steam for the engines, yet all the steam for auxiliaries was taken from the lowest point in the steam main without a separator. There was much complaint about the amount of oil required by these pumps. A pump is a wasteful thing at best, and I cannot see where there is any economy in supplying it with wet steam. If there is some good reason for this I would be glad to learn of it.

Edward Horsfeld.

New Brighton, Penn.

Who Gets the Promotion?

The Foreword in the issue of Dec. 15 is indeed a problem if sentiment is allowed to enter into it, assuming that the promotion is to be to that of chief engineer and the three candidates to be watch engineers. Only one candidate has made any special effort to fit himself for the position and is therefore entitled to it on a strictly business basis.

The one on the left is popular with his mates, a hustler, observing and is liked by the manager, and expects to slide into the job. Being popular with a number of men is no guaranty that he can handle those same men. He will not be taken very seriously, and if he changes his attitude to one of authority they will resent it. Being a hustler is not an essential quality in a chief engineer. His task is to devise ways and means to operate the plant economically and efficiently. His observations are of little value if he lacks the technical knowledge to decide their true significance. The manager has no right to consider his likes or dislikes.

The center candidate is steady, sober and honest, which is probably the reason he has seen long service. Seniority without any indication of ability is no reason for promotion. He has made no effort to fit himself for a better position, therefore has no right to expect promotion. Lacking in ambition, it is not reasonable to suppose he will make an efficient chief. He hopes to fall into the position.

The candidate on the right is qualified in every way, and being a student will be progressive. He, however, is grouchy and will probably have labor trouble; but if the manager understands the principles of coöperation he can explain to this man the effects of grouchiness on the men under him. It is only reasonable to suppose that a man who has the ambition and perseverance to fit himself for the job in every other way will also overcome this fault when he is made to see how objectionable it is. He is the only man who deserves the position; he is trying to climb into it.

S. H. Farnsworth.

Chicago, Ill.

[The foregoing assumes one change is to be made; eliminating a fatal error and substituting a desideratum. Suppose the others to be similarly treated?—Editor.]

Substitute for "Kilowatt-Hour" Suggested

Electricity as sold is usually dependent upon two factors—the full or maximum demand and the extent or hours of use of the demand.

The demand is the force applied in doing work, and the electrical unit for measuring force is the kilowatt. It is thus described in the A. I. E. E. Electrical Standards:

"Electrical power, which is the rate at which energy is being transformed in a circuit, is expressed by the product of the instantaneous values of electromotive force and current in the circuit. The practical unit is the kilowatt, which is 1000 times the watt."

The amount of force or energy expended in doing work is the product of the average force applied and the duration of time during which the force is applied. The electrical unit is the kilowatt-hour, described as follows:

"The amount of electrical energy transformed in a circuit is measured by the product of the power and the time. The practical unit is the joule, which is equal to one watt-second, the watt-hour and the kilowatt-hour."

It may be found convenient in the sale of electric power to charge on the basis of the kilowatt demand alone, the energy in kilowatt-hours consumed alone, or by a combination of the two methods. Nontechnical men who, through the nature of their business, happen to deal with electrical matters often confuse these terms. The kilowatt and the kilowatt-hour, while directly related, have a different significance, and the oversight or unintentional dropping of the suffix "hour" may create a serious and perhaps costly misunderstanding.

For the best interest of the electrical business it seems that an appropriate substitute for the term kilowatt-hour is highly desirable, and it is fitting that the units of quantity of energy be designated as "kelvins," in distinction of the memorable work of Lord Kelvin. This thought had its inception at the last International Electrical Congress and was at that time recommended for adoption and, not unlike the appeal for the substitution of the term myriawatt for boiler-horsepower (although of a somewhat different application), should receive the indorsement and support of the entire electrical industry.

Pittsburgh, Penn. W. B. Wallis.

Engineers' Study Course

Heat-Engine Cycles

The series of thermal and mechanical operations through which the working medium of a heat engine passes is called its cycle. The actual cycle of any working engine has back of it an ideal scheme of operation under which the greatest possible proportion of heat could be converted into work. Between ideal and actual performance there is a gap due to secondary losses resulting from imperfections of the real machine.

The essential parts of the ideal cycles of the common types of engine, with both steam and gas as working mediums, are as follows:

1. Reception of heat at high temperature or over a high range of temperature.
2. Lowering of temperature by adiabatic expansion, in which no heat is given to or taken from the substance, so that it performs work at the expense of its initial store of heat energy.
3. Rejection of heat at low temperature or over a low range of temperature.
4. Raising of temperature to the starting point by adiabatic compression, in which the work done upon the substance adds itself to the initial store of heat energy.

Looking at the matter from the side of thermal action, the simplest case is that in which heat reception occurs at some uniform high temperature and heat rejection at some uniform low temperature. The resulting combination of two isothermal (constant temperature) and two adiabatic (no heat transfer) operations constitutes the well known Carnot cycle, which is, thermally, the simplest possible scheme of working. If T_1 is the absolute temperature of heat reception and T_2 the absolute temperature of heat rejection, the efficiency in heat conversion is

$$E = \frac{T_1 - T_2}{T_1}$$

This means that the quantities of heat received, converted, and rejected are respectively proportional to T_1, $T_1 - T_2$ and T_2.

Fig. 1 is a true representation, laid out to scale, of the performance of one pound of air as medium in a Carnot cycle, when working from 2000 to 1000 deg. abs. F., or from 1540 to 540 deg. F. The pressure limits are from 450 to 15 lb. abs. per sq.in. The purpose in giving it is to show how utterly impractical this cycle is as an underlying scheme for a gas engine. The faults are, first, a very weak variation of pressure from the beginning of the stroke at A to the end of the stroke at C; secondly and especially, the vertical narrowness of the inclosed diagram $ABCDA$ coupled with the high total pressures prevailing, as measured above the base line OV. The small mean effective pressure will require a large cylinder for a given power, and the big total pressures will call for a strong and heavy machine and will cause large losses of power through machine friction. Further and finally, isothermal operations could not well be secured with any scheme of internal combustion. The alternative of treating a gaseous medium like the water in a boiler, and supplying heat through a metal wall from an external furnace, has been tried out in the hot-air engines. While not impossible, this plan is of little value practically.

But with steam, as laid out in Fig. 2, the Carnot cycle becomes of distinctly usable form. This is because constant pressure goes with constant temperature in the isothermal operations of evaporation and condensation. The description of Fig. 2 is as follows:

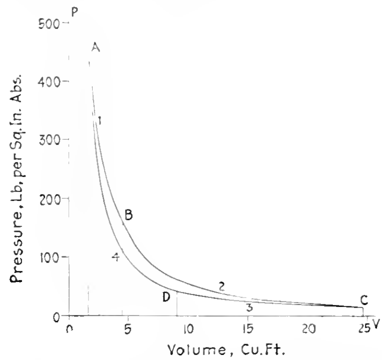


Fig. 1. Carnot Cycle for One Pound of Air

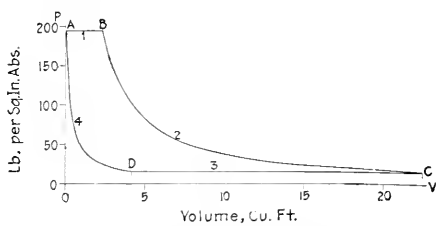


Fig. 2. Carnot Cycle for One Pound of Dry Saturated Steam

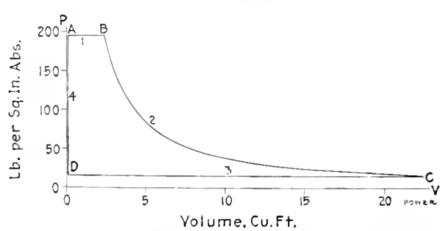


Fig. 3. Rankine Cycle for One Pound of Steam from Fig. 2.

At A is represented the volume of one pound of water at steam pressure and temperature. Line AB represents the vaporization of this water and the admission into the cylinder of the full volume of steam formed.

With ideal action there would be no loss of heat or pressure in the steam pipe or engine valve and no abstraction of heat by the cylinder walls. Of course, no material exists of which the thermally neutral cylinder requisite for such action could be made.

Curve *BC* shows adiabatic expansion carried down to exhaust pressure and temperature at *C*. This continues to require the imaginary nonconducting cylinder. To supply heat for work done there is progressive condensation of steam along line *BC*.

Line *CD* represents not so much the expulsion of exhaust steam from the cylinder as the decrease of volume by condensation. This condensation is stopped at such a point *D* that adiabatic compression of the whole charge of the water-steam mixture will bring it to the initial state at *A*.

Now the real cycle of the steam plant conforms to this scheme as closely as actual conditions and materials will let it, with but one exception. This one essential departure lies in the absence of any attempt to raise the feed water to steam temperature by adiabatic compression. Instead, the steam is all condensed, and the resulting water or an equivalent fresh supply is pumped into the boiler.

Modified thus by the omission of adiabatic compression, the Carnot cycle of Fig. 2 becomes the Rankine cycle of Fig. 3. This is the ideal scheme of working which lies back of the actual performance of the steam plant with either piston engine or steam turbine. Such an engine as the direct-acting steam pump falls far short of the ideal output of work per pound of steam. Good plants range from 65 to 75 per cent. of ideal performance.

Working according to the Rankine cycle, an ideal steam plant would get more work from a pound of steam than if on the Carnot cycle, hence would require fewer pounds of steam per horsepower-hour. But the heat required to make a pound of steam increases more rapidly than the work output, so that the Rankine-cycle efficiency is lower.

It is to be borne in mind that the line *AD* at the left-hand edge of Fig. 3 is not identical with the axis line *OP*. The distance between them is the volume of the pound of water, and operation No. 4 is performed by the feed pump. Of course, this operation no longer conforms to the general description in paragraph 2.

Turning now to internal-combustion engines, the cycle most used is represented in Fig. 4. This is in true proportions for certain assumed data, with one pound of gas mixture. The dotted outline shows approximate dimensions of the real diagram. Heat reception takes place with rise of temperature from *A* to *B*, heat rejection with fall of temperature from *C* to *D*. Operations 2 and 4 are adiabatic expansion and compression, as heretofore. In the actual engine the heating at constant volume is pretty well realized. The would-be adiabatic operations are strongly modified by cylinder-wall action, which is strengthened by the water jacket. The ideal cooling at constant volume from *C* to *D* is approximated in mechanical effect by actual exhaust, no matter just how the heat in the exhaust gases is really dissipated into the atmosphere.

The Brayton cycle, Fig. 5, in which heating and cooling take place under constant pressure, is of little practical interest as regards use in piston engines. It is, however, the cycle of nearly all the attempted gas-turbine plants. In the latter there are necessarily two distinct pieces of apparatus—the compressor, whose operation is represented by diagram *DAEFD*, and the turbine, with diagram *EBCFE*.

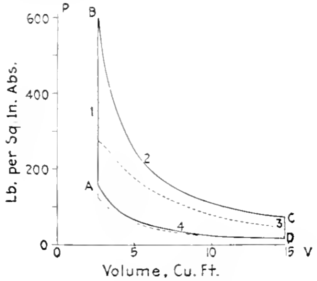


Fig. 4. Ideal Otto Cycle

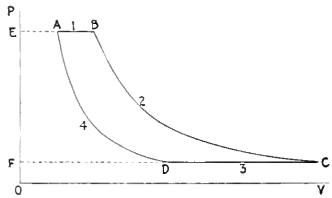


Fig. 5. Brayton Cycle, Used in Gas Turbines

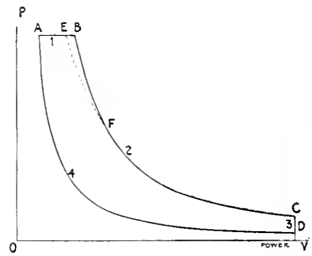


Fig. 6. Diesel Cycle

The Diesel cycle, Fig. 6, calls for little comment. Its heat reception is nearly at constant pressure, although a short isothermal section *EF* is sometimes assumed as a part of the ideal diagram.

The ideal cycle, with its output and efficiency, is not nearly so much used as a standard of comparison for the gas engine as it is for the steam plant. One reason is that it is a much larger task to calculate, exactly, the dimensions of an ideal gas cycle than those of the Rankine steam cycle. Roughly, if T_1 is the average absolute temperature during heat reception *AB*, and T_2 the average temperature during heat rejection *CD*, the efficiency is, as per the Carnot cycle,

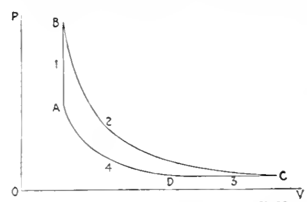


Fig. 7. Cycle of Explosive Gas Turbine

$$E = \frac{T_1 - T_2}{T_1}$$

But this is only a rough approximation; and a large amount of mathematical work is needed to get an exact value.

In the way of a comparison among these cycles, one important point will now be noted. From the side of the machine (as against that of thermal action) that cycle is best and easiest to apply effectively in which the least amount of work must be expended in getting the medium up to its high pressure at the beginning of the working stroke—at *A* in all except Fig. 4, and in this figure at *B*. The steam-engine cycle, Fig. 3, shows up best in this respect, although its apparent advantage is partly neutralized by compression in the cylinder. The latter is not an essential part of the cycle, but one of the secondary sources of loss, like cylinder-wall action, etc.

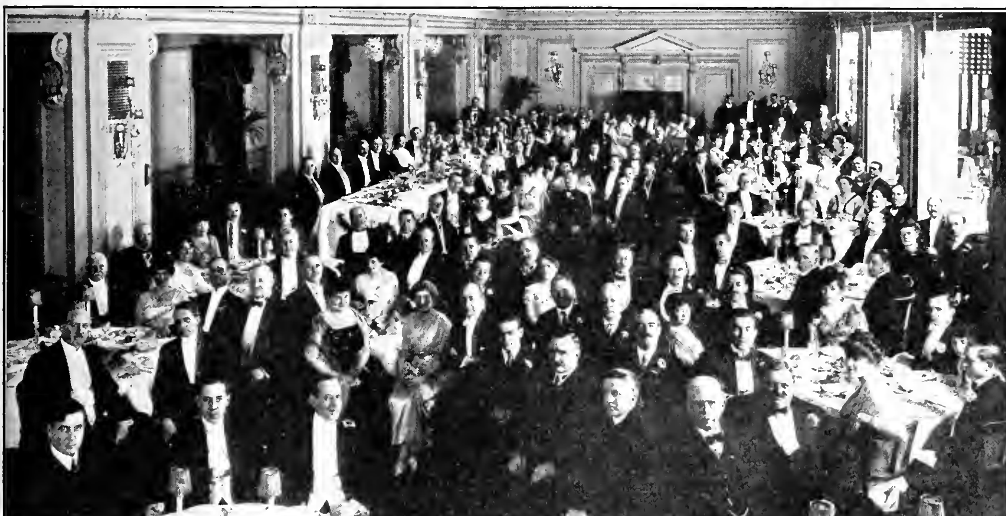
As between gas-engine cycles, the two-part operation *DAB* in Fig. 4 is better than compression clear up to the highest pressure along the curve *DA* in Fig. 5 or *DA* in Fig. 6.

The Diesel engine has advantages which overcome the handicap of excessive compression work. But this handicap is a serious matter indeed for the gas turbine, and one of the chief reasons for its lack of success. It is because of the smaller amount of compression work that the explosive cycle, driving by puffs, has been employed, as in the Holzwarth turbine (POWER, Feb. 9, 1912, p. 191). This cycle is outlined in Fig 7, and the constant-pressure line *CD*, as in Fig. 5 also, has the practical significance that there is a longer range of expansion than of compression.

American Society of Heating and Ventilating Engineers

The twenty-first annual meeting of the American Society of Heating and Ventilating Engineers, held Jan. 19-22, at the Engineering Societies Building, West 39th St., New York City, was attended by 200 to 300 members and guests, and the attractive program which had been announced was carried out in nearly every detail.

At the business session, held Wednesday afternoon, Jan. 20, reports of the secretary, treasurer and council were received and indicated that steady progress had been made in the special field of the Society and that the ambition to increase its membership to one thousand was not without substantial encouragement.



ANNUAL DINNER OF AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

PRESIDENT'S ADDRESS

In his annual address, Samuel R. Lewis, the retiring president of the Society, urged upon the members the advantages of following up the actual operation of heating and ventilating plants, especially those of their own design, as information thus gained is highly beneficial in broadening out personal experience and in establishing the relative merits of different systems. Continuing, he said:

When the designing engineer has more to do with the operation of the plants he designs, there will be an improvement in design. I speak from experience, and believe that this opinion will be shared by others who have had like experience.

An examination of the Society's proceedings discloses many descriptions of new plants, but little information as to their operation or as to the costs of installation or maintenance.

I venture, therefore, to present an analysis of some data. In 1912 two large factory buildings were erected, one in Toledo and one in Detroit, and both were designed by the same architects. The writer designed the heating equipment for both plants.

The character of the construction is identical. There are no basements, but there are some tunnels provided under the first floors for air ducts, service pipes, wiring, etc. The buildings are of reinforced-concrete construction, with solid concrete floors, mushroom type, and 12-in. brick curtain walls. The glass is set in tight, steel frames extending practically from floor to ceiling and from column to column. The ratio of glass to exposed wall is approximately three to one. The roof is of concrete-slab construction, with a cinder fill and tar above.

The Toledo building is heated and ventilated by an all-indirect system, equipped with automatic temperature and humidity control, the humidifying being by means of steam jets. There is no direct radiation whatever, except in a few toilet and service rooms.

The Detroit building is heated entirely by direct radiation, about one-half of the radiation being placed on the side walls and one-half on the ceiling. Great care was taken, however, in placing the radiation on the side walls to provide for a liberal circulation of air behind it. The Detroit building has no automatic temperature control, although good hand regulation is obtainable by shutting off parts of the radiation.

Each plant is equipped with an efficient two-pipe vacuum system. The Toledo plant is unique in its design to the extent that the blast-heating surface is arranged at the bases of the vertical flues and so proportioned that much the same effect is obtained every day as would be obtained by having direct radiators in the various rooms, since gravity indirect heating is always in effect whenever there is any steam in the radiation. The theory in the design was that the Toledo plant should be economical, comparing with direct radiation by reason of this gravity effect, while not open to the objections inherent in direct radiation when placed against the outside walls. These objections are that the direct radiation interferes with the benches of the workmen, causes local overheating, and is not economical of fuel, since there is an opportunity for a large amount of radiant heat to directly enter the outside wall without appreciably affecting the temperature of the room. The air is handled by steam power, and the cost of air handling is included in the fuel cost.

The Detroit plant, with its direct radiation, is, of course, heated whenever supplied with steam. In March, 1914, information was received from the owners to the effect that the heating plants had proven adequate and satisfactory.

A careful record was kept of the fuel consumed during the season of 1913-14. The following data will serve for comparison:

	Toledo With Ventilation	Detroit No Ventilation
Exposed glass surface	39,520 sq.ft.	13,980 sq.ft.
Exposed wall surface	7,904 sq.ft.	2,796 sq.ft.
Exposed concrete-column surface	7,680 sq.ft.	3,600 sq.ft.
Exposed roof surface	45,880 sq.ft.	29,358 sq.ft.
Exposed ground-floor surface	45,880 sq.ft.	29,358 sq.ft.
Contents	2,460,500 cu.ft.	704,592 cu.ft.
Floor area	178,800 sq.ft.	56,955 sq.ft.
Blast radiation	12,983 sq.ft.	
Direct radiation	negligible	8,905 sq.ft.
Air delivered per minute	138,000 cu.ft.	
Boiler capacity	500 hp.	125 hp.
Cost of coal per season	$3,009.00	$952.00
Fuel cost for heating and ventilating per 1000 cu.ft. of contents per season	$1.22	$1.35
Same per thousand sq.ft. of floor space per season	$16.82	$16.73

So far the evidence is favorable to a blast system as indicating that a large, well built factory building can be heated and ventilated with an efficient, all-indirect plant at less cost per thousand cubic feet of space per season and for nearly the same cost per thousand square feet of floor space per season, as the other can be only heated by plain direct radiation.

The economy of the Toledo plant lies in the form of the building; that is, the Detroit building, being but two stories high, loses heat through the floor of the first floor and through the ceiling of the second floor, whereas the Toledo building, being four stories high, has two intermediate stories which only lose heat around their sides. For this reason there is advantage sufficient in the instance under consideration to make a favorable showing for the blast system.

REPORTS OF COMMITTEES

The report of the committee appointed January, 1914, "to prepare a set of minimum ventilation requirements for public and semipublic buildings which the Society can recommend for legislation," was received with interest.

General Statement of the Committee on Compulsory Ventilation

A correct interpretation of the experimental work which has been carried on in the last few years, relating to ventilation practice, forces certain conclusions:

A. The necessity for adequate ventilation has been emphasized, although the relative importance of certain factors has changed.

B. A high temperature, especially if associated with a high relative humidity, is injurious.

C. The proper relation between air temperature and relative humidity should be emphasized.

D. Air movement in contact with the body materially assists normal heat dissipation.

E. Air supply free from dust, bacteria and other contaminations is important.

In making recommendations for compulsory ventilation laws it is believed that the importance of the following requirements has been amply demonstrated:

1. A minimum allotment per person of floor and air space, based upon the nature of occupancy.

2. A quantitative minimum air-supply requirement.

3. A carbon-dioxide test for determining the quantity of air supply and its distribution.

4. A temperature-range limitation.

5. The removal from the air of injurious substances arising from manufacturing processes or other causes.

6. Air-exhaust requirements for special service rooms (toilets, locker rooms, etc.).

7. Definite requirements regarding the drawing, filing and approving of plans for both new and existing buildings in which ventilating equipments are to be installed or changes in the equipment made.

8. Ample authority to enforce the law without recourse to civil action, and with sufficient operative and financial assistance to care for the clerical, field and technical details incurred by such enforcement.

9. The official body charged with the enforcement of such laws shall have authority to promulgate specific rules and regulations covering details of installation and operation not included in the law. Such rules and regulations must not conflict with the full intent and meaning of the law. (A few such rules are appended to the report.)

The committee decided that it would be impracticable to attempt to draft a model ventilation law with the necessary legal phraseology, as this would require the assistance of an attorney, and would, moreover, call for an extensive building classification which could not be satisfactorily used in the various states, cities or towns where building laws and regulations based on other classifications are now in force. The committee submitted, first (under Section I), the specific report covering general suggestions for minimum heating and ventilation requirements that are applicable to all classes of buildings, and secondly (under Sections II, III and IV), separate sets of more definite requirements for schools and colleges, factories and theaters.

Sections II, III and IV cover three very important classes of buildings which are often the subject of separate legislation. Many other classes of buildings, such as department stores, hospitals and similar institutions, churches, restaurants, police stations, jails, bakeries, laundries, etc., for which the requirements for heating and ventilation are covered by careful interpretation and use of Section I, would be benefited by separate sets of requirements. It was also pointed out that suggestions from the Society, covering practical requirements for the heating and ventilation of street cars and some other public conveyances, are desirable, and that the report could be considerably enlarged to cover these subjects.

The committee strongly urged that educational and coöperative methods of improving heating, ventilation and sanitation conditions be studied, and used as far as possible in addition to compulsory methods.

Various members of the Society and others had assisted in the compilation of these recommendations, and the information had been cheerfully given when available. The committee also reported that acknowledgments were especially due to investigations and recent committee reports concerning the work in New York City and to the ventilation code and experience in the City of Chicago.

The General Suggestions, Section I, of the Committee's Report, applicable to all classes of buildings, to be provided and maintained during occupancy in all rooms and all inclosed spaces in all classes of buildings, are summarized as follows:

Article I—Space per Occupant (minimum requirement)—

Schools and colleges—class, study, lecture and recitation rooms, floor area per occupant in sq.ft.	15
Schools and colleges—class, study, lecture and recitation rooms, cubic space per occupant (volume divided by number of persons) in cu.ft.	180
Primary schools—class and study rooms (pupils under 8 years of age), floor area per occupant in sq.ft.	12.5
Primary schools—class and study rooms (pupils under 8 years of age), cubic space per occupant in cu.ft.	150
Theaters, auditoriums and courtrooms, floor area per occupant in sq.ft.	6
Theaters, auditoriums and courtrooms, cubic space per occupant in cu.ft.	90
Factories, manual-training rooms and other workrooms—floor area per occupant in sq.ft.	25
Factories, manual-training rooms and other workrooms—cubic space per occupant in cu.ft.	250

Minimum space conditions in all classes of buildings or rooms not tabulated shall be reasonable and practical and shall meet the approval of the Department of Health.

Article II—Air Supply (minimum requirement)—

Sufficient outdoor air shall be provided for all occupied rooms or inclosed spaces at all times during occupancy, as may be necessary to meet the requirements of Articles I to XI, inclusive.

The supply of outdoor air for the following classes of rooms shall be positive and based on a minimum quantity of cu.ft. per occupant per hour as tabulated:

Class, study, lecture and recitation rooms in all schools and colleges, cu.ft. per occupant per hour	1800
Courtrooms and auditoriums	1500
Theaters	1200
Factories, manual-training rooms and other workrooms	1500

All air supply for ventilation must be from an uncontaminated source of air from which the dust or other impurities shall be sufficiently removed by washing or otherwise.

Article III—Air Distribution—

The distribution and temperature of the air supply for ventilation shall be so arranged as to maintain the temperature requirement, as stated in Article IV, without uncomfortable drafts, or any draft lower than 60 deg. F., and as a test of proper supply and distribution it shall be required that the CO_2 content shall not at any time exceed 10 parts in each 10,000 parts of air, based upon tests taken in a zone from 3 to 6 ft. above the floor line in the occupied spaces. This requirement may be modified by the properly constituted authority as applying to breweries, water-charging rooms or other rooms where carbon dioxide is liberated in manufacturing processes.

Note—While carbon dioxide in the air, in reasonable quantities, is not considered injurious to health, its presence in occupied rooms is an acccurate measure of the air supply and distribution if no other source of carbon dioxide is present except the occupants of the room.

Article IV—Temperatures—

The temperature of the air in occupied rooms in all classes of buildings, during the periods of occupancy, shall be not less than 60 deg. F., nor more than 72 deg. F., except when the outside temperature is sufficiently high that artificial heating in the building is not required, this requirement not to apply to foundries, boiler or engine rooms, or special rooms in which other temperatures are required or advisable.

Articles V to XIV provide suggestions pertaining to regulations on the subjects of sources of heat; removal of dust, fumes, gases, vapors, odors, fibers or other impurities; prevention of excessive temperature and humidity; ventilation of special-service rooms; ventilation of toilet rooms; ventilation of cellars, basements and spaces under buildings; authorization to require special ventilation; filing of plans; investment of officials with the right to inspect premises; authorization of officials to close premises after noncompliance with regulations and due notice.

A report was submitted by the committees on the Development of Heating and Ventilating Industrial Buildings, and progress was reported by other standing committees.

In a brief paper presented by A. M. Feldman on an experiment with ozone as an adjunct to artificial ventilation at Mt. Sinai Hospital, New York City, the author recited details of experiments and observations upon which he unhesitatingly recommended the use of ozone as an efficient deodorant, which he believed was beneficial in general improvement of air conditions when properly used, and harmless in physiological effects.

The observations of the author precipitated some discussion of the old question of whether the action of ozone was a destruction of baneful conditions or a mere masking of odors. Dr. M. W. Franklin ably described experiments made by him which demonstrated by comparatively simple chemical processes and analyses that compounds consisting of most disagreeable and deleterious exhalation are so broken up by ozone as to be destroyed and not merely compensated.

A well illustrated paper was presented by D. D. Kimball, author of Part I, and George T. Palmer, chief of investigating staff, author of Part II, on "Results of Physiological and Psychological Observations during the First Year's Experiments" by members of the New York State Commission on Ventilation. The investigation was made possible through the generosity of Mrs. Elizabeth Milbank Anderson, who gave to the Association for Improving the Conditions of the Poor of New York the sum of $550,000 for various phases of social investigation, $50,000 of which is to be expended in an investigation of the problems of ventilation.

This commission, consisting of Professors C. E. A. Winslow, F. S. Lee, E. L. Thorndike, E. B. Phelps, Dr. James A. Miller and D. D. Kimball, was organized early in the summer of 1913, and steps were immediately taken to provide a laboratory equipment for the conduct of the studies and the experiments. The experimental plant was installed in rooms of the biological laboratories of the College of the City of New York. It was aimed to provide atmospheric conditions with temperatures from that existing out of doors or less up to 100 deg. F. in zero weather, with humidities varying from the saturation point to practically nothing. The illustrations and descriptions of the apparatus and methods employed for creating the desired conditions, selection of subjects, tests and data are all of highest scientific interest to physiologists, employers, heating and ventilating engineers, and the public generally, in determining the influences of different air conditions and advantages of controlled systems of ventilation.

In the first experiment, the efficiency in mental work of four subjects, young men about 18 years of age, students of the College of the City of New York, was compared in five different atmospheric environments, viz.: 68 deg. F. and 50 per cent. relative humidity with ample air supply (about 45 cu.ft. per min. per person); and the same temperature and humidity, no air supply (i.e., a stagnant condition); 86 deg. F. and 80 per cent. relative humidity with ample air supply, and also with no air supply; and 86 deg. F., 80 per cent. humidity, no air supply (a stagnant condition but with small electric fans blowing air on the faces of the subjects).

The experiments were thus planned to give information on the subjects' efficiency in (1) a hot moist room as compared with a cool room, (2) a room with ample supply of fresh outdoor air as compared with a room in which no air at all was supplied, and (3) a hot moist room where relief was afforded by the moving air from electric fans. The relative effects were determined by (1) measurement of mental accomplishments, (2) measurement of physiological responses and (3) recording the opinion of the subject as to state of comfort.

In addition to the above six, other sets of tests were conducted, with conditions varied to correspond with extreme conditions of outdoor and indoor atmosphere during the warmest season of the year.

The results of each series of experiments bring out strongly the fact that temperature, and not chemical composition of the air, exerts the greater influence on the physiological responses and that no distinct differences exist between fresh and stagnant air, as far as pulse and blood pressure are concerned; that more food is eaten at the lower temperatures, and the increased consumption on the days with air supply is even more striking; that when the subjects were urged in their work, about one-third more was done at 68 deg. than at 86 deg. F.; that no falling off of judgment was indicated by exposure to the hot conditions, the slightly better score even favoring the warm days and the days with air supply; that room temperature fails to influence mental efficiency, although the feelings of the subject differ materially, favoring the lower temperature. The results also showed that while high temperature and even 75 deg. measurably affected certain physiological reactions of the body, mental processes were not impaired. In fact, with the same relative humidity (1) the 75-deg. condition is somewhat preferable for tasks involving deep concentration, such as mental multiplication; (2) the 68-deg. condition is slightly more desirable for combined mental and motor tasks such as typewriting; (3) that the difference between the two temperatures is practically negligible for maximum effort tests involving mental processes similar to those used in additions of columns of figures, and that there is no choice between these two variables so far as the physical comfort of the subject is concerned.

Application of the inclination-to-do-work test to physical studies was instituted to analyze the effects of the 68-deg. and 75-deg. temperatures and the importance of air supply. These tests consisted of (a) accomplishment of voluntary physical work, (b) variations in appetite, (c) effect of extreme exertion on rate of pulse recovery, and (d) effect on various physiological responses. The results of the work tests show that when left free to occupy their time either at work or rest, the subjects performed 15 per cent. more work at 68 deg. than at 85 deg., and that 2 per cent. more work was done when air was supplied.

In their summary of results the authors state that it is difficult at this time to arrive at any sweeping conclusions as to the importance of different ventilation factors. The influences of humidity have not been studied at all to date. The first year's work of the commission has, however, developed these facts:

1. Temperature within the range from 86 deg. to 68 deg. F. has a marked effect on certain physiological responses.

2. Stagnant air, lacking a definite disagreeable odor but containing all the products of the exhaled breath, including carbon dioxide in excess of 30 parts per 10,000, is objectionable in a manner as yet unknown but demonstrated by a lessened desire for food, but otherwise shows no debilitating effect on the mental process nor on the various physiological reactions which have been studied in these experiments.

ELECTION OF OFFICERS

Officers for the year 1915, as reported by the nominating committee, were elected as follows: President, Dwight D. Kimball, New York; first vice-president, Harry M. Hart, Chicago; second vice-president, Frank T. Chapman, New York; treasurer, Homer Addams, New York. Managers—Frank Irving Cooper, Boston; Dr. E. Vernon Hill, Chicago; W. M. Kingsbury, Cleveland; Samuel R. Lewis, Chicago; Frank G. McCann, New York; J. T. J. Mellon, Philadelphia; Henry C. Meyer, Jr., New York; Arthur K. Ohmes, New York.

The first paper considered at the evening session of Jan. 20 had for its subject "The Centrifugal Fan," by Frank L. Busey, and had been prepared for presentation before the Society just previous to the death of its author. The paper was read by W. H. Carrier, who stated that a very considerable portion of the data consisted of results of the author's personal investigations. (Most of the leading features of the paper are given by the author in an article by him, which was published in the Aug. 11, 1914, issue of "Power," pp. 200-204.) Several members spoke in the highest terms eulogistic of the author's attainments and the work which he did as a valuable member of the Society. The paper was ordered to be printed in the "Transactions," and by a rising vote of all present the thanks of the Society were tendered to Mrs. Busey for her act of providing the Society with the manuscript.

A paper on "Engine Condensation," by Perry West, elicited a spirited discussion, in which several members took issue with the author's deductions leading to the statement:

> It will be seen from the foregoing that in passing high-pressure steam from a boiler through a system of piping and thence through a reciprocating engine, a considerable heat loss is encountered, which usually results in a considerable percentage of condensation in the exhaust. I should say that with simple engines this would run between 15 per cent. and 20 per cent. This means, of course, that there is never as much steam available for the heating system as is started with at the boiler, but just this amount of condensation. Besides this, the steam is in a very moist condition, due to the presence of this water.

David Moffat Myers, the author of the succeeding paper, presented by discussion and in his paper, "The Heating Value of Exhaust Steam," statements and conclusions which were considerably at variance with the deductions of Mr. West, claiming that the latter's method of estimating heat remaining in the exhaust of an engine were unwieldy, and when estimates are based on data which have been established for the thermal efficiencies of engines, the average of Mr. West's estimates for the heat loss of simple engines would be found about 8 per cent too high.

"A Study of Heating and Ventilating Conditions of a Large Office Building" was the subject of a paper presented jointly by C. E. A. Winslow and G. F. Maglott, in which the authors call attention to the facts that the progress of the art of heating and ventilation has been seriously retarded by the gap which, unfortunately, often exists between design and operation. Excellently planned systems may fail on account of changes in conditions of occupation or carelessness in upkeep and management; while on the other hand, operation sometimes reveals shortcomings in design which should be instructive in the planning of future installations. Careful studies of actual results obtained are none too common. The authors present such a study of a large business office building in New York City, heated in the main by direct steam radiation, with certain rooms on the lower floors in part indirectly heated by plenum air supply.

A scientific investigation showed, as all too often is the case, that both the heating and the ventilating systems had been allowed to fall into such disrepair and to become so ill adjusted to present needs as to fall far short of realizing the purposes for which they were designed. It is just such conditions as these which constantly bring discredit upon the art of heating and ventilation, and they are conditions which can only be brought to light by comprehensive engineering and sanitary study of actual operation.

Other papers presented and discussed were: "Studies in Air Cleanliness," by G. C. and M. C. Whipple; "Problem of City Dust," by R. P. Bolton; "Cinder Removal from the Flue Gases of Power Plants," by C. B. Grady; "Recirculation of Air in a Minneapolis School Room," by Frederic Bass; "Comparative Tests of Various Types of Exhaust Ventilators for Sleeping Cars," by Dr. T. R. Crowder; "Ventilation of Industrial Plants," by T. Graham-Rogers, M. D.; "Test of a Cast-Iron Sectional Down-Draft Boiler," by C. A. Fuller; "Crude Oil Fuel," by H. S. Haley; "Some Phases of Room Heating by Means of Gas Burning Appliances," by George S. Barrows; "Rational Methods Applied to the Design of Warm Air Heating Systems," by Roy E. Lynd; "Tests on Threading Steel and Wrought-Iron Pipe," by C. G. Dunnells; "Capacities of Steam Pipes at Different Pressures," by James S. Otis.

ENTERTAINMENT

The entertainment committee provided a program for out-of-town members and guests, which included social sessions, shopping tours for the ladies, theater parties and visits to points of interest. The annual dinner, which was held at the Hotel McAlpin on the evening of Thursday, Jan. 21, was attended by nearly 200 members and guests and proved to be one of the most enjoyable events in the history of the Society.

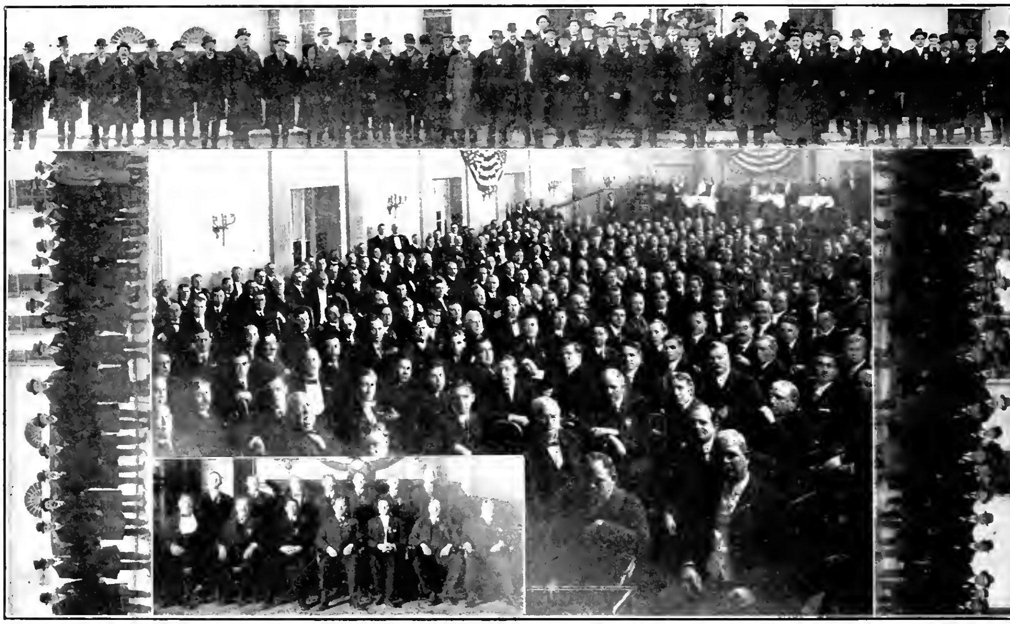
National Marine Engineers' Convention

The National Marine Engineers' Beneficial Association of the United States of America convened in its fortieth annual session on Monday, Jan. 18, at 10 a.m., at the Raleigh Hotel, Washington, D. C. The following officers occupied their respective chairs: William F. Yates, president; George H. Bowen, second vice-president; Charles N. Vosburgh, third vice-president; George A. Grubb, secretary; Albert L. Jones, treasurer.

The several daily sessions of the delegates were from 9:30 a.m. to 1:30 p.m. There were present 60 delegates, representing 115 votes from all of the large lake and river cities of the United States. The financial report showed the organization to be in a prosperous condition. Many matters of special interest to the association were discussed and disposed of with harmony and dispatch.

On Thursday morning an adjournment was taken by the delegates to permit of the convention visiting the White House to be presented to President Woodrow Wilson. There was a theater party on Monday evening to Keith's Vaudeville House for everybody, and on Wednesday evening there was one exclusively for the ladies. The smoker on Thursday night tendered to the engineers by the Supplymen was the big event of the convention, and was heartily enjoyed by all. Fully 400 delegates and invited guests assembled in the ballroom of the Raleigh, where the "New York Bunch" of entertainers made things lively, and kept the audience in good humor for the entire evening. Good things to smoke and drink were served plentifully.

At the session on Wednesday morning the following national officers were elected: A. Bruce Gibson, president, San Francisco, Calif.; E. M. Roberts, first vice-president, New York City; C. N. Vosburgh, second vice-president, New Orleans, La.;



THE MARINE ENGINEERS' BENEFICIAL ASSOCIATION'S FORTIETH CONVENTION

Group outside the White House after being received by the President—The new National Officers—The Smoker at the Raleigh Hotel

William C. Wilson, third vice-president, Philadelphia, Penn.; George A. Grubb, secretary, Chicago, Ill.; Albert L. Jones, treasurer, Detroit, Mich.

The advisory board includes: Thomas L. Delahunty, New York City; George H. Willey, Boston, Mass., and Robert L. Goelet, Norfolk, Va.

The trustees of the "American Marine Engineering" comprise Clinton E. Thurston, Norfolk, Va.; Joseph G. Myers, Charleston, S. C., and William Murray, New York City.

The forty-first annual convention will meet at Washington, D C., the week beginning Jan. 17, 1916.

General Electric Co. Exhibit for Panama-Pacific Exposition

The exhibit of the General Electric Co. in the Transportation Building at the Panama-Pacific International Exposition will comprise electric locomotives for various classes of service, including steam-railroad electrification, railway motors and all kinds of apparatus and accessories for electric railways, signal accessory electric devices, electric apparatus and equipment for railway shops, electric illumination for cars and shops, etc.

One of the electric locomotives is one of four recently built for the Butte, Anaconda & Pacific R.R. and is a duplicate of the original 17 units put into service in 1913. These are the first 2400-volt, direct-current electric locomotives ever built. Each unit weighs 80 tons, and two are coupled together for freight service hauling trains of 4600 tons at 16 miles per hour up a 0.3 per cent. grade, and at 21 miles per hour on level track. Two passenger locomotives, operating as single units on this system, are geared for a max'mum speed of 45 miles per hour on level track.

Down with the Archaic Boiler Horsepower

We are rapidly drawing away from the horsepower method of rating boilers. This has come about through the working of two different tendencies, both of which diminish the value of such a statement of boiler capacity. In the first place, there no longer exists any particular equality between the horsepower of a boiler and the amount of engine power which it may be expected to serve, although at the time of the adoption of the present unit, in 1876, it was given a value about equal to the average steam consumption per horsepower of the engines exhibited at the Centennial Exposition, on the assumption that this would approximate average conditions at that time. Modern engines have so far improved in economy that it is now possible for one boiler horsepower to serve from two to three engine horsepower of connected load under favorable circumstances. There is, moreover, another influence at work to lessen the value of the horsepower rating—namely, the growing demand for greater and greater boiler output per unit of heating surface—so that it is no longer a matter of special novelty to read test returns of boilers in regular operation at upward of 200 per cent. of what a few years ago would have been considered a proper performance.

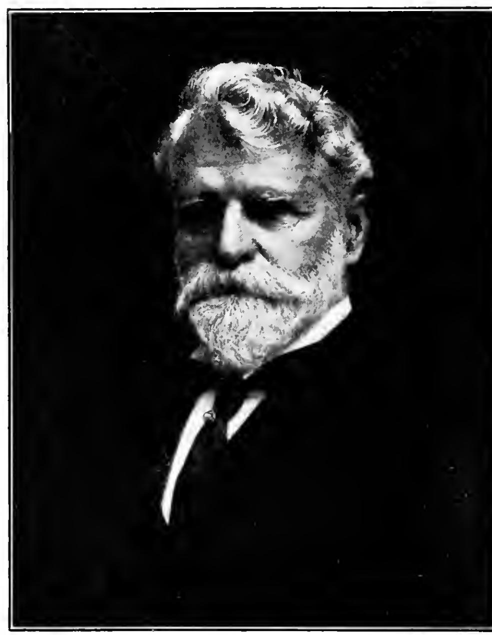
The result of these two changes in power-plant economics is to make it more and more necessary to plan boiler plants on a heating surface and not a horsepower basis. The designing engineer first determines the rate at which he expects to be able to work his heating surface, with the character of coal, draft, setting, etc., which he expects to utilize; that is, he sets a figure for the amount of water which he may expect to evaporate on each square foot of heating surface in the particular plant he has in mind. It is then only necessary to add the combined water rates of the different steam-consuming devices and divide by the evaporative rate to arrive at the total heating surface, which he can divide among the proper number of boilers.

When an essentially nontechnical buyer of boilers is obtaining competitive bids from boiler makers, he is apt to think and talk in terms of dollars per 100 or 150 (or some other number) horsepower. He naturally assumes that this is a proper basis upon which comparisons may be made. He will of course be disappointed if, having purchased the boiler from the lowest bidder, he finds to his surprise that this builder has bid on a boiler rated at 10 sq.ft. to the horsepower, while perhaps his engineer in deciding on the necessary size has calculated on 12 sq.ft. to the horsepower rating. This is very confusing to the owner who is not an engineer or who is not familiar with the diversity which exists among boiler makers as to the proper rate of evaporation to use as the foundation for a catalog rating. It is not at all uncommon for the condition outlined above to come about, resulting in the purchase of a boiler 20 per cent. smaller than either the buyer or his engineer desired.—"The Locomotive."

The Engineering Foundation

The ceremonies inaugurating the Engineering Foundation were held Wednesday, Jan. 27, at 8:30 p.m., in the auditorium of the Engineering Societies Building in New York City. The name, The Engineering Foundation, has been given to a fund "to be devoted to the advancement of the engineering arts and sciences in all their branches, to the greatest good of the engineering profession and to the benefit of mankind." The administration of this fund will be intrusted to the Engineering Foundation Board elected by the trustees of the United Engineering Society, the holding corporation of the Engineering Societies Building, and composed of eleven members, two each from the American Society of Civil Engineers, the American Society of Mechanical Engineers, the American Institute of Mining Engineers and the American Institute of Electrical Engineers, two members chosen at large, and the president of the United Engineering Society, ex-officio.

Gano Dunn, president of the United Engineering Society and past-president of the American Institute of Electrical



Ambrose Swasey

Engineers, presided, and announced for the first time the name of the donor of the initial gift of $200,000—Ambrose Swasey, who is widely known as a member of the firm of Warner & Swasey, of Cleveland, Ohio, prominent machine-tool builders and the foremost builders of telescopes in the world. Among the instruments which they have designed are the famous Lick, Yerkes and United States Naval Observatory telescopes, as well as the 72-in. reflecting telescope for the Canadian Government, which is now under construction. In addition to his engineering achievements, Mr. Swasey is known for his practical efforts toward scientific education and the advancement of the profession. His gift for the establishment of The Engineering Foundation is in line with these undertakings, which may be destined to outlast his fame as an engineer.

In response to the ovation given Mr. Swasey at this time, he arose and made an acknowledgment of his appreciation of the spirit in which the announcement had been received. Other speakers of the evening were: Dr. Henry S. Pritchett, president of the Foundation for the Advancement of Teaching. Dr. Robert W. Hunt, past-president of the American Institute of Mining Engineers, Charles MacDonald, past-president of the American Society of Civil Engineers; and Dr. Alexander C. Humphreys, past-president of the American Society of Mechanical Engineers.

Following the ceremony a reception to Mr. Swasey was held at the platform of the auditorium. A testimonial dinner to him was given on the preceding evening by the president and board of trustees of the United Engineering Society, at which speeches were made by leading engineers representing the civil, mining, mechanical and electrical branches of the profession, which helped to further cement the close relationship existing and gave promise of hearty cooperation in the future on all matters affecting the profession in general.

Rolling-Mill Engine Wrecked

Early in January the compound condensing engine driving a train of hot rolls at one of the plants of the American Sheet and Tin Plate Co., at Chester, W. Va. (near East Liverpool, Ohio), was badly wrecked, caused by the breaking of the strap on the crosshead end of the connecting-rod.

When freed from the rod the crosshead and low-pressure piston were driven through the low-pressure cylinder, breaking it beyond repair, also the distance piece between the high- and low-pressure cylinders. The high-pressure cylinder was not so severely damaged, because the studs which held it to the bedplate gave way and allowed the cylinder to recede. It was torn from the bedplate and its steam connections at the throttle and receiver pipe.

The engine was built by C. & G. Cooper and had been in use about 14 years. It was 26&54x60-in. and ran at 65 r.p.m., carrying a 22-ft. flywheel weighing about 60 tons, and was geared to a shaft driving six hot mills. A steam pressure of 140 lb. was carried, exhausting into a Worthington condenser.

Fortunately, no one was injured, but the mill will be shut down for fully four weeks, during which time about 500 men will be idle. Our representative was, unfortunately, unable to procure photographs, as the work of clearing away the wreckage and reconstructing the engine was begun at once and all haste was made to get the mill in operation again.

PERSONALS

F. W. Rose, of the firm of Rose & Harris, engineers, Auditorium Building, Minneapolis, has been elected secretary and treasurer of the Minnesota section of the American Society of Mechanical Engineers.

Errett L. Callahan, for the past six years manager of the new business department of H. M. Byllesby & Co., Chicago, Ill., has resigned that position to become Chicago district manager for the Westinghouse Lamp Co.

David A. Wright, for several years with the Yale & Towne Manufacturing Co., of New York, as district manager in the West, has engaged in business for himself as manufacturers' agent, at 149 South Dearborn St., Chicago, Ill. He is specializing on labor-saving and pneumatic machinery, cranes, hoists and trolley systems.

E. P. Roberts, commissioner of smoke abatement, Cleveland, Ohio, has tendered his resignation, to take effect Feb. 1, and will resume business as a consulting engineer, with temporary address 2053 East Ninety-sixth St., Cleveland. In addition to general power-plant engineering as heretofore, he will make a specialty of smoke abatement.

Dr. Edward Weston, of Newark, N. J., has been presented with the ninth impression of the Perkin medal, given for distinguished service in chemistry and electrochemistry. The ceremony took place on Jan. 22, at the Chemists' Club, Dr. G. W. Thompson presiding. The medal was presented by Doctor Chandler, senior past-president of the Society of Chemical Industry, after briefly reviewing the career of the recipient.

ENGINEERING AFFAIRS

The Western Society of Engineers, Chicago, has elected the following officers for the year 1915: President, W. B. Jackson; first vice-president, Ernest McCullough; second-vice president, Charles B. Burdick, third vice-president, P. B. Woodworth; treasurer, C. R. Dart, trustees, F. E. Davidson (one year), H. S. Baker (two years), O. P. Chamberlain (3 years).

Railroad Night for Chicago Section A. S. M. E.—Jan. 8 was railroad night for the Chicago section of the American Society of Mechanical Engineers. As usual, it was a dinner meeting held in the Louis XVI room of the Hotel La Salle. There was a large attendance and a number of able speakers. S. G. Neiler presided. The subjects discussed were: The Locomotive Superheater, Locomotive Stokers, and Railway Economics. The subject first named was introduced by R. M. Ostermann, of the Locomotive Superheater Co. C. F. Street, president of the Locomotive Stoker Co., gave some statistics on the cost of operation when using stokers and outlined the advance that had been made in this field. Railway Economics was discussed at length by W. A. Smith, president of the "Railway Review."

Technology Clubs Convention—The Technology Clubs Associated, an organization of former students of the Massachusetts Institute of Technology, will hold a reunion in Pittsburgh Feb. 19 and 20, at the invitation of the Pittsburgh Association. The main features will be: Class luncheons the first day; course luncheons the second day where discussion of the various curriculums will be undertaken and where graduates, in the light of their later experiences, will be invited to criticize their own courses of instruction; and the banquet Saturday evening, when addresses will be given by President Richard C. Maclaurin and probably President A. Lawrence Lowell, and two other speakers of international prominence whose names are to be announced later. All alumni and former students of the institute are invited.

International Engineering Congress—The American Society of Mechanical Engineers has issued a circular letter to its membership, urging individuals to subscribe to the International Engineering Congress to be held in San Francisco in connection with the Panama-Pacific International Exposition, Sept. 20 to 25, 1915. As one of the five national societies in the hands of the representatives of each of which the Congress is placed, it is urged by the mechanical engineering society that its members should feel responsibility and give their fullest support to the Congress. The fee for membersnip is $5, which entitles a member to the index volume which covers general proceedings, indexes and digests, and any one of nine other volumes which are published or to be published, as follows: Vol. 1, The Panama Canal; Vol. 2, Waterways and Irrigation; Vol. 3, Railways; Vol. 4, Municipal Engineering; Vol. 5, Materials of Engineering Construction; Vols. 6 and 7, Mechanical and Electrical Engineering; Vol. 8, Mining Engineering and Metallurgy; Vol. 9, Naval Architecture and Marine Engineering; Vol. 10, Miscellaneous.

TRADE CATALOGS

Skinner Engine Co., Erie, Penn. Catalog. Universal Unaflow engine. Illustrated, 28 pp., 8½x11 in.

The Emerson Electric Mfg. Co., St. Louis, Mo. Catalog No. 6700. Electric fans. Illustrated, 48 pp., 7x10 in.

Kennedy Valve Mfg. Co., Elmira, N. Y. Catalog. Gate, globe, angle, radiator and corner valves. Illustrated, 124 pp., 6x9 in.

B. F. Sturtevant Co., Hyde Park, Mass. General Catalog No. 195. Fans, exhausters, blowers, engines, steam turbines, etc. Illustrated, 116 pp., 6½x9 in.

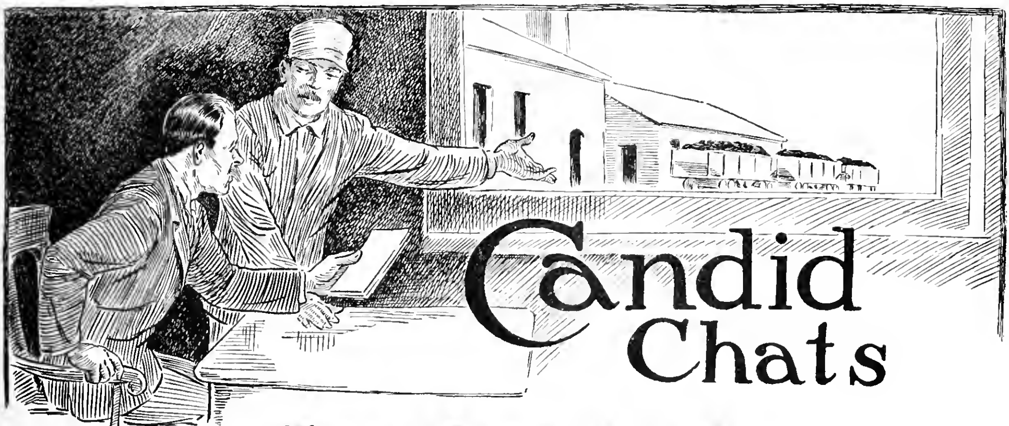
Armstrong Cork & Insulation Co., Pittsburgh, Penn. Booklet. "Permanent Fortifications." Nonpareil corkboard insulation. Illustrated, 8 pp., 3½x6 in.

CONTRACTS TO BE LET

TREASURY DEPARTMENT, Supervising Architect's Office, Washington, D. C., January 5, 1915—Plans and specifications are now approaching completion for a central heating, lighting and power plant, to be erected in this city under the direction of this office. These plans and specifications will be ready for delivery on or after January 15. Bids may be submitted for the entire work or for any one of the following sections: Power plant building complete, with steel stacks; boilers; generating apparatus; pumping equipment; condensers; coal and ash handling apparatus; steam and water piping; switching gear; tunnels; substation apparatus, etc. Prospective bidders should immediately submit to this office applications for plans and specifications, stating the portions of the work upon which they desire to bid. If it appears that the applicant is in a position to bid on all of the work in any one of the sections of the project, or upon the entire work, the plans and specifications will be forwarded. No plans or specifications will be furnished sub-bidders or others not in a position to submit a bid on all of the work comprised in at least one section. The Department will be able to allow only about 15 days for the preparation of estimates. At the time plans and specifications are forwarded to bidders the date for the opening of bids will be stated, and this date will not be extended. O. WENDEROTH, Supervising Architect.

POWER

Vol. 41 NEW YORK, FEBRUARY 9, 1915 No. 6



Too Much Coal

Here is an amusing yet pathetic story which you'll appreciate all the more if you know of a similar case

THE plant is the ordinary large, industrial kind where much low-pressure steam is used for manufacturing purposes. The management—the president and the usual outfit—is representative of the average.

The new chief engineer was engaged on a salary and percentage-of-saving basis. Of course, the first thing he did was to return to the boiler the many pounds of 210 deg. F. condensate allowed to merrily flow to the sump and sewer. Winter was coming on, and one need not be a college professor to know that changes in pipe sizes and arrangements and the installation of a few traps on the heating system would make the coal man feel badly.

The volume of business was fairly constant, and had been for years, so the coal was bought by contract and supplied in unvarying amounts as regularly as you get sleepy between 2 and 3 a.m. when you are on the 12-to-8 watch. The coal was stored in a large low building and had to be trimmed considerably to fill it. Soon the effect of the changes in the uses of steam and the disposition of condensate was made apparent by the full coal cars on the siding and the labor necessary to trim coal in the storage bin. The amount of coal on hand was becoming a veritable nuisance!

The chief asked the manager to have the supply stopped for a while. This was a new one on the manager; the engineer's complaint had always been the other way, and the manager did not understand. Couldn't the engineer find room for it somewhere? The quantity received was as usual, and he could prove it by comparing the monthly statements. The mills ran full time; the winter was just as cold as previous ones, if not colder. He glanced at the calendar to make sure it was Feb. 1 instead of Apr. 1, and finally walked to the window to see that string of cars. Yes, the coal was there! Ah! he had it; the coal was not being used!

The engineer suggested that they compare the weekly coal consumption reports. Yes, the manager was right; the coal was not being used as formerly. The reports showed that up to date about one hundred tons less coal had been used these last winter months than for the corresponding months of previous years.

What does this case show? Here is an actual, honest-to-goodness example of the amount of worth-while attention some concerns pay to the power plant.

And the engineer was engaged on a percentage-of-saving basis, too!

It shows that the engineer must keep duplicate reports and, above all, see to it that the management really studies them and is given every opportunity to know what their proper interpretation means in its relation to the chief engineer and the cost of manufacture.

This engineer had applied himself to the task of reducing costs and improving service, had stayed up late nights outlining necessary alterations to this end—he was making good! And he was getting no more moral credit than the man who would have used the 100 tons and saved disturbing the manager. Things would have gone this way until the books were examined to determine how much in percentage-of-saving was due the engineer.

Seattle Municipal Lighting Plant

By W. L. Kidston

SYNOPSIS—This plant will assist in carrying the winter peak loads of the Cedar Falls (Wash.) hydro-electric plant. A steam pressure of 200 lb. is carried on the three boilers, with 125-deg. superheat. The turbo-generator is of 7500-kw. capacity. The boiler furnaces are designed for burning fuel oil or coal with mechanical stokers, which can easily be put in place.

The new steam-generating station of the Seattle (Wash.) municipal system, known as the Lake Union auxiliary, has a continuous capacity of 9375 kw. and will be used by the lighting department to help the main hydro-electric station at Cedar Falls over the heavy winter peaks and to take its full capacity load in case of accident to the water-power station or transmission lines. The steam plant is near the geographic center of the city, on the east shore of Lake Union It will be accessible from Puget Sound and Lake Washington through the Lake Washington canal, and by land it can be reached by the Lake Union belt-line railway and by the tracks of the local traction company.

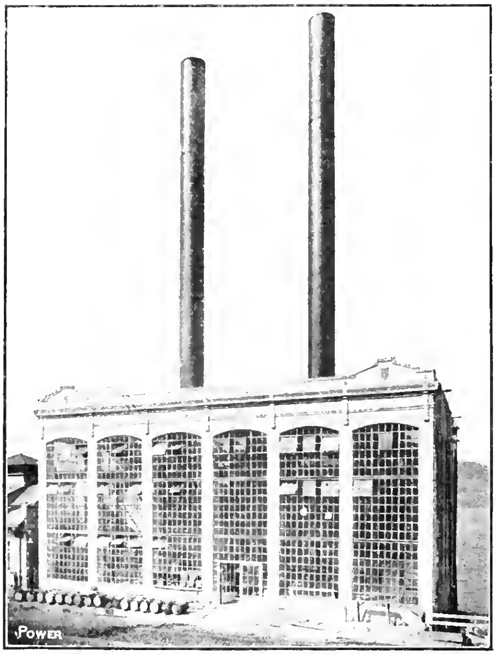


Fig. 1. New Seattle Generating Station

The building (Fig. 1), built of reinforced concrete, is 90x100 ft. and 57 ft. from the basement floor to the cornice and was begun on Apr. 25 of last year. It was designed and built by the Department of Buildings of the city of Seattle. The foundation is on piles. The basement floor is 18 ft. below the level of East Lake Ave., and a concrete retaining wall containing 800 cu.yd. was built to support the street and protect the structure from possible slides from the hill beyond. Steel sash is used throughout the building, and as the space between columns is glazed, ample light is secured. A 25-ton crane with a 30-ft. span serves the turbine room.

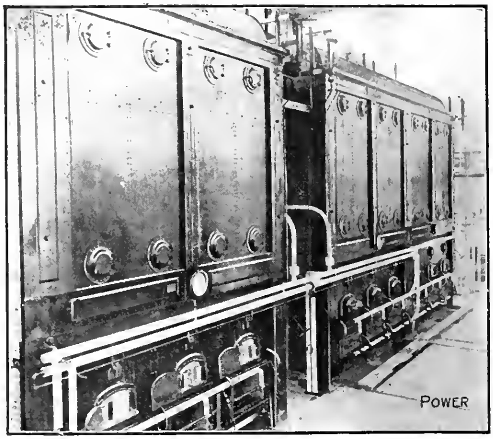


Fig. 2. Three Water-Tube Boilers with 8230-Sq.Ft. Heating Surface

The plant contains three water-tube boilers (Fig. 2), each having 8230 sq.ft. of heating surface, which will supply steam at 200 lb. pressure and 125 deg. superheat to the 7500-kw. turbo-generator set (Fig. 3). The boilers are on the street floor at the west side of the building, with the firing aisle next to the lake. They are equipped for burning oil, but the settings are arranged for stokers and ash hoppers, so that a change may be made to coal burning at any time by inserting the stokers, the tracks for which are in place. The basement under the boilers is planned to accommodate the ash-handling cars. Provision is made for a fourth boiler. The boilers are guar-

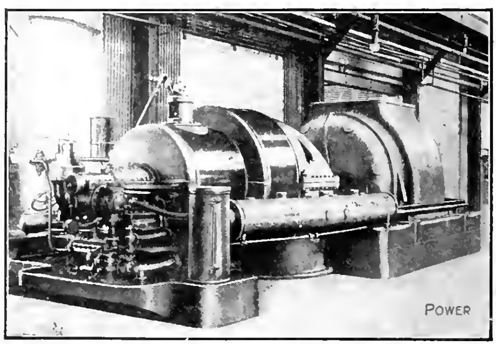


Fig. 3. The 7500-Kw. Turbo-Generator Unit

anteed for 77 per cent. efficiency at full load and to operate satisfactorily at 180 per cent. continuous overload. Two steel stacks, 90 in. diameter, designed for coal burning, extend 170 ft. above the boiler-room floor, each to care for two boilers.

Two steel oil-storage tanks, 11 ft. and 20 ft. long, of 15,000 gal. capacity each, are buried just outside the boiler room on the south side of the building. Both tanks have domes 4 ft. in diameter and 4 ft. high, with screw covers and steel ladders to permit of inspection. This capacity per tank is the largest allowed by the city ordinance. As the tanks are adjacent to the building, it was necessary to bury them, and a concrete wall was built, separating and inclosing them. The space around the tanks was then filled with earth to a depth of 4 ft. above the top of the shells. Six-inch connections to the domes are used for filling the tanks and connections of the same size on the under side join with an 8-in. suction header, to which the two motor-driven storage pumps, each with a capacity of 16,000 gal. per hour, are connected. This header runs out to the lake for use in unloading oil-tank cars or oil scows.

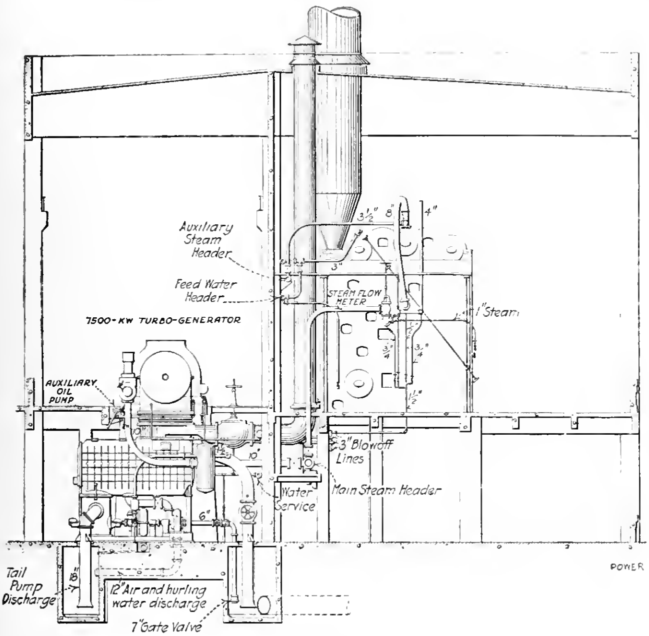


FIG. 4. ELEVATION OF THE BOILER ROOM AND BASEMENT

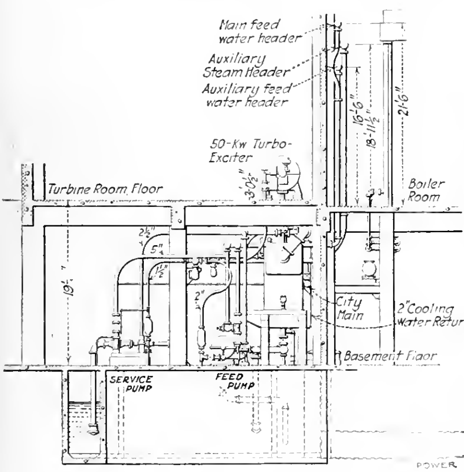


FIG. 5. END ELEVATION OF AUXILIARY PIPING

One 7200-gal. service tank, 7 ft. in diameter by 24 ft. long, is placed above the storage tanks, and the suction pipes from the two burner pumps run through the dome and down to the bottom of the tank, terminating in a foot valve. The tank is separated into halves by a partition, thus forming two tanks, both of which have a 30-in. dome with a screw cover. A steel ladder runs to the bottom of the tank. The 6-in. connections in the domes are used for filling the tanks and the 4½-in. suction pipes for emptying them. A 2½-in. overflow pipe runs from each oil heater back to the service tank. A 6-in. pipe from the filling pipes to the street makes it possible to fill any of the three tanks from oil trucks. Pumps to supply the oil burners are on the boiler-room floor, as are the oil heaters.

The boilers connect to a 12-in. header (Fig. 4), from which steam is taken to the turbine (Fig. 7). The generating unit is a horizontal turbine connected by a flexible coupling to a 2500-volt, two-phase alternator, at 1800 r.p.m., and rated at 7500 kw. at 80 per cent. power factor with 50-deg. Centigrade rise above the room temperature, and at 9375 kw. at 80 per cent. power factor with 65-deg.

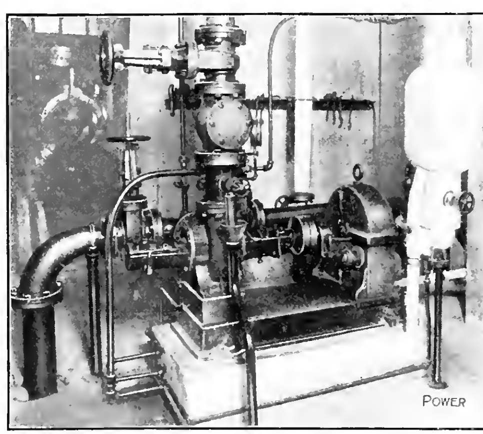


FIG. 6. TURBINE-DRIVEN HOUSE PUMP

rise. The temperature in the generator coils is measured by a resistance thermometer inserted between them, and is registered on the switchboard. The unit is guaranteed to produce one kilowatt-hour from 12.95 lb. of steam at 190 lb. pressure and 125 deg. superheat when operating at full load.

The condenser, of the rectangular-jet type, and placed under the turbine (Figs. 4 and 5), will maintain 28½ in. of vacuum when condensing 97,500 lb. of steam per hour.

The centrifugal circulating pump is mounted on the shaft with the rotary air pump and both are driven by a small impulse turbine. The boiler-feed pumps and the service pump (Figs. 6 and 9) are also of the centrifugal type with four stages, and are turbine driven. Steam for these auxiliaries is taken from a 6-in. saturated-steam header, and the exhaust is used in the 2500-hp. metering feed-water heater. The exciter, rated at 50 kw., 125

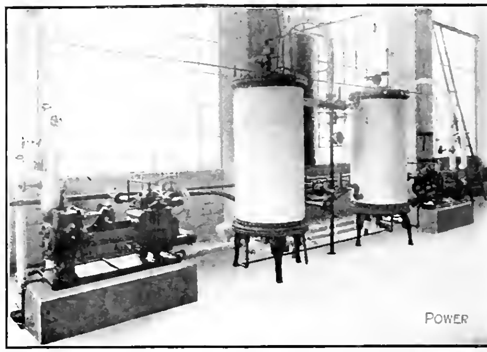


FIG. 7. OIL HEATERS AND PUMPS

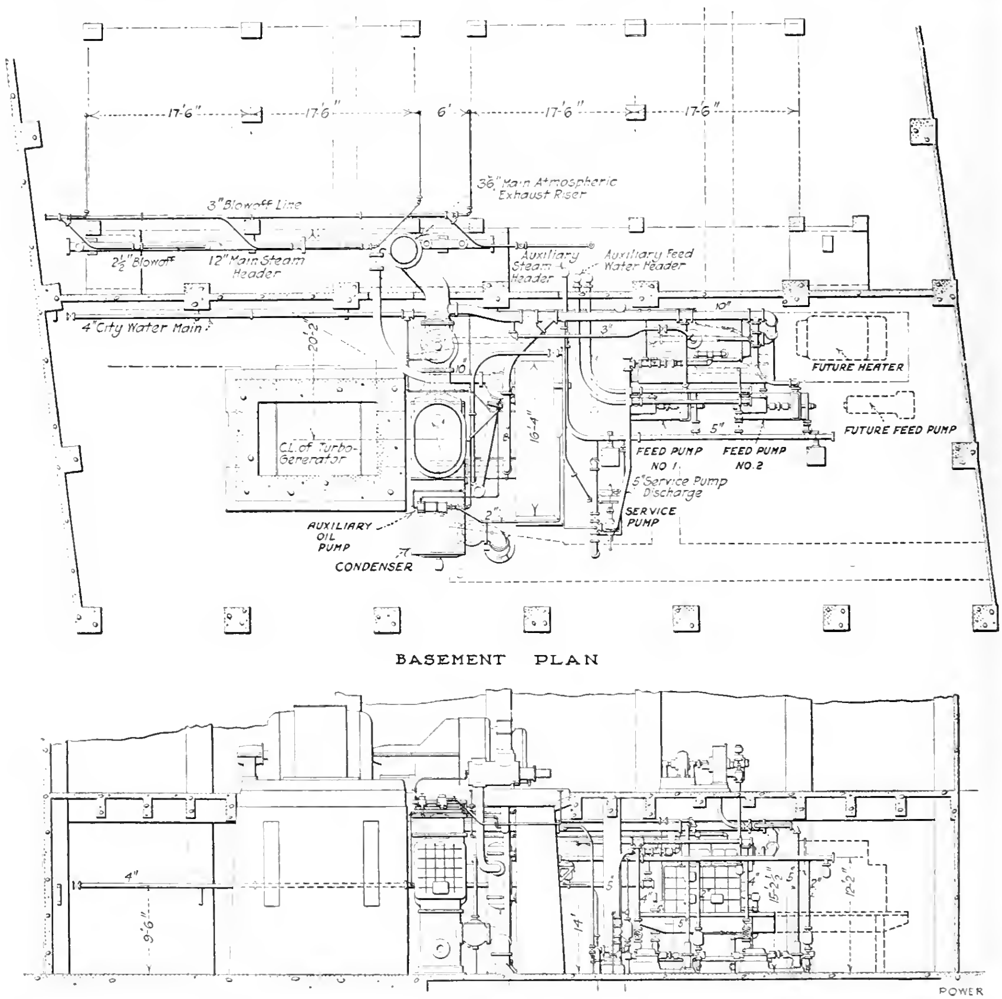


FIG. 8. PLAN AND ELEVATION OF TURBINE-ROOM BASEMENT

volts, is also turbine driven. Fig. 8 shows the piping arrangement.

As the steam-plant site is on the shore of Lake Union, a fresh-water lake, there is an abundant supply of cooling water for the condenser. The water supply is brought to the plant from an intake 120 ft. out in the lake, through a 30-in. cast-iron pipe to a concrete screen box at the west side of the building, and from there through a second run of pipe to a cold well at the end of the condenser. An 18-in. pipe supplies the condenser with cooling water, which is drawn into the condenser by vacuum. In starting, a jet of water from the city mains is used to condense

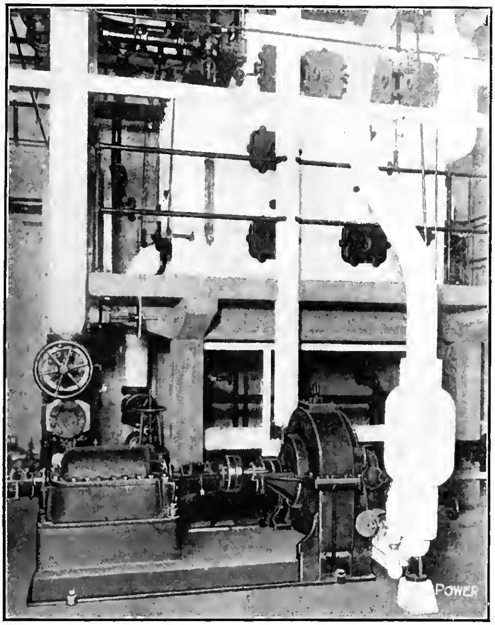


Fig. 9. One of the Two Turbine-Driven Centrifugal Boiler-Feed Pumps

the steam and create a vacuum in the condenser shell. The 18-in. discharge pipe from the condenser connects with the hotwell, which is a concrete tunnel 4 ft. wide by 10 ft. deep. In case of a future installation, this tunnel will connect the two units. A 30-in. cast-iron pipe serves as an outlet for the hotwell and discharges the hot water into the lake at the back wall of the building.

The turbine set is on the street floor, on the east side, next to East Lake Ave., and the switchboard is in the same room. Current is stepped up to 15,000 volts, two-phase, for distribution over the city, and the steam station will be connected to the main distributing station at Seventh Ave. and Yesler Way by a direct 15,000-volt tie line. The step-up transformers, of the same capacity as the turbine, are in the basement under the turbine room, where the oil switches and 2500-volt and 15,000-volt wiring are placed. Provision is also made to use the steam station for distributing, for which purpose the oil switches, feeder regulators and street-lighting transformers will go in the basement.

The steam plant is on the same lot with a 1500-kw. water-power auxiliary, which uses the overflow from the Volunteer Park reservoir of the city water system, situated on the hill 415 ft. higher than the lake. Both plants will be operated from the same switchboard and will work together to safeguard the service of the system.

The main generating station at Cedar Falls is being extended and improved by the erection of a $1,100,000 dam, which will permit of a development of 40,000 kw. J. D. Ross, superintendent of lighting, is in charge of the Seattle municipal plant.

First-Aid Jar for Power Plants

Accidents frequently happen in and about a power plant, and in many cases the injured could be attended by the laymen if first-aid materials were at hand. A first-aid jar has been prepared to meet such requirements by the Conference Board of Safety and Sanitation, of which Magnus W. Alexander, General Electric Co., West Lynn, Mass., is secretary.

The jar is structurally strong and a special annealing treatment makes the glass still stronger. It is made with smooth surfaces and with straight walls on the inside to promote cleanliness and facilitate the removal of first-aid materials. A convenient carrying handle is molded to the glass cover, held by suitable spring clips which are a part of a metal cage holding the jar; this cage affords added protection against breakage. A rubber gasket between the jar and the cover makes the outfit dustproof.

The jar is made only high enough to accommodate the bottles of medicaments stored in it so that the stoppers

First-Aid Jar

cannot come out when the cover rests on the jar. Medicine bottles, bandages, absorbent cotton, burn ointment in collapsible tubes and a wire-gauze splint are arranged along the wall of the jar, so that they are plainly visible from the outside and can be quickly located. A specially constructed metal dish placed inside of the jar keeps the materials in their proper places; it is also used as a receptacle for tourniquet, medicine glass, gauze bandages, medicine droppers, spoon, scissors, etc.

The jar is about 9½ in. in diameter, 6 in. high, and complete with contents weighs only slightly more than 12 lb. It, however, includes every material which a conference of physicians with extensive experience in the treatment of injuries agreed upon as necessary for effective first-aid treatment by laymen.

Suitable first-aid instructions are printed on the inside of the cover, while on the outside appears the standard list of materials which should always be kept in the jar and brief directions for the use and care of the outfit.

This jar has been approved by the board, which is composed of representatives of the National Founders' Association, 29 South La Salle St., Chicago; the National Association of Manufacturers, 30 Church St., New York City; the National Metal Trades Association, Peoples Gas Bldg., Chicago, and the National Electric Light Association, 29 West 39th St., New York City. The outfit is sold at practically cost price, as there is no intention to make a profit on any of the articles standardized by these associations, and can be secured by writing the secretary of any of the associations mentioned.

Oil-Engine Tendencies

By A. E. Ward

SYNOPSIS—The writer reviews the oil-fuel situation and points out the legitimate fields for the different types of engines. He warns against the defects in the low-compression, pump-injection type when attempting to use heavy oils, which should be used only in the high-compression engine, and champions the vaporizing type.

The manufacture of internal-combustion engines is being influenced to a certain extent by the fuel situation, and the consequent demand of the public for an engine which will handle heavy grades of liquid fuels. Whether this demand is to continue will be influenced by the availability of the heavy liquid fuels, their prices as compared with lighter fuels, and the success of the engines which claim to use them. Therefore, it would be well for the buying public to consider carefully and without prejudice all phases of this subject before it continues to bring about what may prove an undesirable tendency in the application of the internal-combustion engine for general power purposes.

Oil-Fuel Situation

During the past few years there have been marked changes in the oil-fuel situation, and it is practically impossible to prophesy what the future will develop. The heavy drain on the gasoline supply for the automobile trade has been the apparent cause for its rise in price. However, this has now been reduced to practically the figures which prevailed several years ago, but it is still too high to be considered for use in the larger or intermediate sizes of internal-combustion engines.

An important feature is the percentage of fuel of different grades available from crude oil. Refiners have been able to secure in recent years a larger percentage of gasoline from crude oil than heretofore, but the quality of the gasoline has also been reduced. Crude oil from different localities varies greatly in quality, but a fair average would indicate that about 15 per cent. can be turned into gasoline or naphtha. About 45 per cent. is kerosene, and about 10 per cent. of a high-grade distillate above 39 deg.; another 10 per cent. is a low-grade distillate below 39 deg; while about 15 per cent. is turned into lubricating oil, and the remaining 5 per cent. is slop. It is evident, therefore, that a small percentage of the refined product, about 10 per cent., is of such a nature as to require a crude-oil engine. Furthermore, about 50 per cent. of the refined product can be handled in the conventional four-stroke-cycle vaporizing type.

There is a large market for the heavier grades of refined oil to be used for burning under boilers, oiling streets, etc., which often makes it difficult for the small purchaser to secure, or to continue to secure, this fuel for power purposes. Sometimes the small purchaser finds that it is necessary to buy his fuel in tank-car lots in order to gain the point of economy desired. It is evident, therefore, that the purchaser of an engine designed for handling crude oil or an equivalent fuel is necessarily subjected to the caprices of the market.

It is true that there are a number of localities, especially in the West and Southwest, where the heavy liquid fuels are being purchased at comparatively low prices. However, it is questionable whether this condition will continue, inasmuch as the supply of fuel oil to burn under boilers has frequently been taken away from manufacturers who have gone to the expense of installing boiler appliances for burning this fuel. Moreover, there is wide variation in the quality and constituents of heavy oils, depending upon the quality of the crude, the method of refining, tendency of the refineries in accordance with the demands, etc.

While gasoline is also uncertain in its price, kerosene has remained at practically the same price, has always been available in most localities, and does not vary in quality.

There are, undoubtedly, many cases where the Diesel engine is the proper type to use, considering especially its high thermal efficiency and the ease with which its fuel can be stored, transported and handled. The following objections can be raised against it, however. It is complicated in design, necessitating strict attention to the minutest details and requires a very high grade of workmanship. Moreover, correct adjustment must be maintained at all times, and skilled attendance with corresponding high cost is essential. Fuels of low quality and low price have frequently been used when the plant was first installed, and later a high-grade fuel has been substituted. Depreciation and maintenance have in many cases been excessive in addition to the first cost being high. Finally, this type of engine is extremely sensitive to irregular or improper conditions.

In spite of these objections there are many successful Diesel installations. If a purchaser takes these points into consideration, arranges to keep the engine in prime condition at all times, is assured that the proper fuel will be available at a low price, if natural gas is not available, and his conditions do not favor producer gas, and if his power requirements are not less than 100 hp., he may be justified in purchasing a Diesel engine.

Semi-Diesel Engines

Coming now to a class of engines for powers of 15 to 100 hp., the purchasers of these sizes ordinarily do not give the engineering features due consideration. Being without the necessary experience and knowledge themselves, they are largely at the mercy of the ambitious salesman who has a tendency to exaggerate the qualifications of the article he is handling. There has been a clamor for engines of those sizes which will burn heavy fuels, such as have been successfully handled in the Diesel engine. Owing to this demand, there has been a natural response on the part of some manufacturers to produce

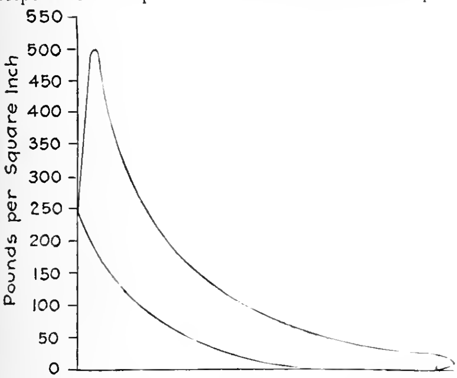


Fig. 1. Diagram from Hot-Plate, Air-Injection Engine at Rated Load

an engine which would fulfill these requirements. It is evident that the high first cost of the Diesel engine would prohibit its sale among the majority of purchasers who desire engines of this size.

There is said to be from 400,000 to 500,000 hp. in engines of the Diesel type used in Europe. There are also a number of these engines in this country, but the fuel situation in Europe is such as to necessitate the use of an engine of this type to a far greater extent than has been the case in this country. It has been repeatedly reported in this country that in engine installations of the Diesel type it has been found desirable to use a lighter grade of fuel than was originally intended. This is brought about by the fact that less trouble and less close attention are required with the lighter and higher-grade fuels. This being the case with an engine which employs extreme methods in order to burn the fuels economically and satisfactorily, how can it be at all satisfactory to handle such fuels in an engine where these methods are not employed?

In an attempt to reduce the cost of manufacture, and still satisfy the demands for an engine which will run on heavy liquid fuels, attempts have been made to depart from the Diesel principle. The first attempt was to change the compression from 500 to 300 lb. This reduction in compression means that the fuel does not burn immediately upon entering the combustion space, as the heat of compression is not sufficient, and in order to obtain the desired temperature a hot plate is projected into the cylinder.

This type retains the air system of fuel injection. A two-stage air compressor is used, which discharges at approximately 600 lb. directly through the fuel valve and against the hot plate in the cylinder. The quantity of fuel is measured in a manner similar to that of the Diesel engine. This system avoids the necessity of carrying such high injection air pressure, but there is only a partial burning of the fuel, and an explosion takes place, the initial pressure depending on various conditions, such as the timing of the fuel injection, the nature of the fuel, the temperature of the engine, the temperature of the hot plate and the compression temperature. An indicator diagram from such an engine is shown in Fig. 1.

If an engine of this type is built as heavy as it should be to withstand the high pressures, and if all other parts are properly designed and constructed, the first cost is almost as high as the Diesel.

An extreme departure from the Diesel principle is the two-stroke-cycle engine using the hot bulb, pump fuel injection, water injection, in the majority of cases crank-case compression, and light construction with a compression ranging from 70 to 150 lb., and in some cases 300 lb. In order to start this engine it is necessary first to heat the hot bulb externally, which requires ordinarily from 15 to 20 min. Sometimes difficulty with the burners necessitates a much longer time.

Two-Stroke-Cycle Principle

The main reason for the four-stroke cycle having been so universally adopted is that the scavenging of the burnt gases can be accomplished by one stroke of the main piston. This leaves the entire volume swept by the piston free for a fresh charge.

The two-stroke-cycle engine which draws the fuel into the crank case and depends upon scavenging the burnt gases by means of air is necessarily uneconomical, because it is difficult to cut off the exhaust gases at exactly the proper point and avoid all passage of the fuel through the exhaust port. However, when the fuel is injected on the compression stroke, and pure air only is drawn into the crank case, this objection is not so serious. Nevertheless, it is difficult to determine just what air currents take place inside the cylinder when it is expected that the incoming air on the one side will drive out the exhaust gases on the other, especially when both of the ports are at one end of the cylinder. Fig. 2 illustrates what probably happens in such a case.

Fuel Injection

Now, consider the fuel injection and the method of forming an explosive mixture. The conventional vaporizing type of four-stroke-cycle engine draws in a charge of air past a fuel spray nozzle at a high velocity, frequently as high as 12,000 to 15,000 ft. per min. This high velocity, together with the extremely fine spraying of the fuel, causes each particle of air to become laden with a certain amount of fuel vapor, and thus promises a very complete mixture.

On the other hand, in the engine with pump injection the combustion space is filled with a mixed charge of air and exhaust gases, with probably some irregular stratification of the exhaust gases. The fuel pump measures out a given quantity of fuel, which is sprayed into the compressed air by a hammer blow from a cam or eccentric which operates the pump. A certain mixture of fuel with the air and burnt gases takes place, but a thorough mixture of the fuel with the air does not exist (see Fig. 3). Furthermore, this mixture will vary greatly from one impulse to the next, depending upon conditions such as stratification of the charge, temperature of the hot bulb, temperature of the engine itself, nature of the fuel used, amount of fuel measured out and injected by the pump, size of the opening in the spray nozzle, condition of the spray nozzle, time in the cycle at which the fuel is injected, etc. All conditions being uniform, the results are fairly satisfactory, but there is necessarily susceptibility to these varying conditions.

These engines are ordinarily rated at a mean effective pressure of 35 to 40 lb., or about half that of a four-stroke-cycle engine of the vaporizing type at rated load. Indicator diagrams from properly designed four-stroke-cycle engines of the vaporizing type show that the mean effective pressures are practically uniform, although in some cases a pressure of 118 to 120 lb. may be indicated. Fig. 4 is a diagram from a two-stroke-cycle vaporizing engine at rated load. Mean effective pressures as high as this are extremely rare, however, and could not be depended upon. This point is brought out to show that the mean effective pressures from the two-stroke-cycle hot-bulb engines are necessarily variable. Furthermore, it is possible to obtain extremely high initial pressure if water injection is not used properly, if the fuel is injected a little too early, or if the temperature of the hot bulb is not correct. Considering that it is possible for these high pressures to exist, the engine should be built heavy to withstand them: irregular impulses mean uncertain service. Fig 5 shows these varying mean effective pressures.

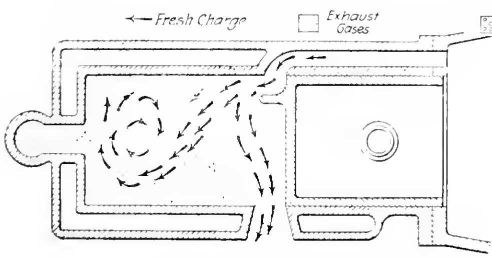


Fig. 2. Results in Two-Stroke-Cycle Exhaust-Scavenging Type of Engine

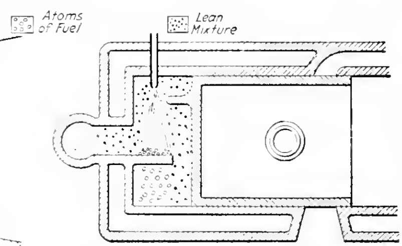


Fig. 3. Showing Small Volume of Air with Which Fuel Comes in Contact in Pump-Injection Type

Measuring the Fuel

Next consider the method of measuring the fuel. Some engines govern by changing the stroke of the pump; others through bypassing a certain amount of the fuel back to the tank. If six drops per stroke is a full load supply for a 10-hp. engine, it will readily be seen how delicate the adjustment must be to govern the speed by reducing the proportion of the six drops in accordance with the load conditions.

If the vaporizing type of engine is properly designed, the correct amount of fuel will be automatically picked up as the throttled air passes over the injection nozzle. This is so automatic that the results are dependable even under adverse conditions.

Timing of Fuel Injection

Different manufacturers commence injecting the fuel at different points in the stroke varying from the beginning of the compression stroke to about 10 deg. before the end of the compression stroke. The proper timing depends upon numerous conditions, such as compression pressure, temperature of the hot bulb, shape of the hot bulb and combustion space, location of the spray nozzle, grade of fuel, diameter of pump plunger, stroke of pump, etc.

Electric ignition is practically instantaneous, and if there is a variation of say 10 deg. in timing, the results obtained are apt to be poor. With an engine running at 300 r.p.m., 10 deg. is equivalent to 0.002 sec. This is an extremely short time for a mechanical fuel pump to act and deliver a quantity of fuel against 150 lb.

It is difficult for anyone who has not worked with them to appreciate the delicacy of these mechanical devices. If the injection of fuel takes place slightly early, in comparison with the temperature of the hot bulb, the amount of water injection, the temperature of the engine and the load, etc., excessive pressure will result.

The Hot Bulb

The mission of the hot bulb is to furnish the high temperature to assist in vaporizing heavy fuels. If its temperature becomes too high, the engine will pound heavily, due to excessive initial pressure. The hot bulb will sometimes have a tendency to crack, due to distortion, because of the unequal temperatures, and also the fuel may decompose and form deposits on the hot spoon, so as to cause cracking of the bulb. Because of this the hot bulb is occasionally the source of annoyance and irregular operation.

Water Injection

If the injection of the fuel could be accurately timed, so as to bring about the proper flame propagation, and if this fuel could be introduced into the cylinder in sufficiently large quantities in the very short time existing at the end of the compression stroke to prevent too early ignition, water injection would not be necessary. Engines that use air injection with the fuel do not use water. Water injection is the handiest means of avoiding excessive pounding and high initial pressure, provided the timing of the fuel injection and the temperature of the hot bulb, etc., are not correct. It is frequently used in large quantities, and when the quantity is too great excessive wear of the cylinder and piston will take place, due largely to interference with proper lubrication. In proper quantities it probably has some tendency to loosen the carbon, and, in accordance with a theory which has frequently been advanced, it may result in bringing about a uniting of the nascent oxygen with the carbon,

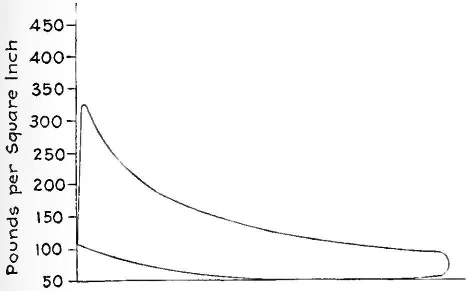


FIG. 4. DIAGRAM FROM TWO-STROKE-CYCLE VAPORIZING ENGINE AT RATED LOAD

thus keeping the cylinder slightly cleaner than would otherwise be the case.

Lubrication

Some years ago the auxiliary exhaust port in the four-stroke-cycle engine was considered good practice, and was extensively used. However, this port was later abandoned because it interfered with proper lubrication, and a dry streak through the cylinder was invariably found where these ports existed. The conditions in this respect are no different than in the two-stroke-cycle engines of today, although probably this port does not bring about so much excessive wear of the cylinder and piston as do the unburnt fuel and the water. Where crank-case compression is used, trouble with the lubrication of the main bearings is sometimes experienced.

Even with very short connecting-rods and with every available space in the crank case filled up so as to obtain as high a compression as possible, it is seldom possible to obtain a pressure in the crank case greater than 2¼ to 2½ lb. With the wear on the bearings, this pressure has a tendency to leak out and to interfere with their lubrication.

Leakage of crank-case compression also has a tendency to seriously affect the operation of the engine, as the transfer air is thereby lost and scavenging is not obtained.

This condition in conjunction with the filling up of the exhaust port with carbon, thus causing back pressure, has a tendency to equalize the pressures on both sides and interfere with proper scavenging. Incomplete scavenging means loss of power, wasted fuel, over-heated engine and premature ignition.

Compression

The compression employed by different manufacturers varies from 70 to 150 lb., some running as high as 300 lb. One manufacturer provides means of varying the compression in accordance with the fuel used and the conditions of operation. High compression should mean greater economy, but at the same time greater danger of excessive pressures. The amount of compression permissible will depend upon the temperature of the hot bulb, the temperature of the engine itself, the grade of fuel used, the method of injecting the fuel, and the time at which the fuel was injected. In consideration of these varying conditions, it is practically impossible to settle upon a satisfactory all-around compression.

Compression undoubtedly has greater influence upon economy than any other one point in connection with the design of internal-combustion engines. When the explosion engine was first attempted, no compression was used, and the engine was practically a failure on this account. Some fuels will ignite more readily than others, and, consequently, are more susceptible to heat of compression. Producer gas will stand a compression of from 150 to 160 lb., and natural gas 120 to 130 lb. without premature ignition. When liquid fuels are introduced into the cylinder of a four-stroke-cycle engine on the suction stroke, a compression of from 60 to 70 lb. is approximately all that can be obtained. Because of this low compression, an economy of less than 12,000 B.t.u. per b.hp.-hr. cannot be expected.

When high compression can be used, such as 120 lb. on natural gas, an economy of 8500 B.t.u. can be expected. This is the economy, therefore, which an engine of the pump-injection type should be able to obtain when using a compression of 150 lb. This economy is not attained, however, because the pump-injection principle is so far from perfect. In fact, it is seldom that an economy of 12,000 B.t.u. is had; the more common figure being 14,000 to 16,000 B.t.u.

Fuels

It is common for manufacturers of the hot-bulb type to state that any fuel can be handled in these engines. Most assuredly, any oil which contains heat units will vaporize when it comes in contact with a red-hot surface, and will consequently develop pressure and deliver power.

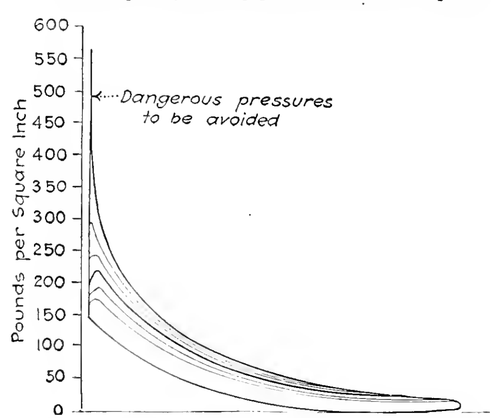


FIG. 5. DIAGRAMS FROM PUMP-INJECTION ENGINE; HEAVY LINE SHOWING EXPANSION CURVE AT RATED LOAD

This being the case, demonstrations can be made on very heavy fuels. Their continued success and satisfaction are, however, highly improbable, and in many cases lighter grades of fuel have been resorted to because less difficulty is experienced.

Can these engines operate successfully on kerosene? is a question which has been frequently asked. The majority of them do not, if they are built for operation on the heavier fuel. The flame propagation of kerosene is more rapid than with fuel oil or a heavier grade of distillate. This fact interferes with operation on either grade of fuel, as the flame propagation is dependent upon the temperature of the hot bulb, the timing of the injection of the fuel, the temperature of the cylinder walls, the amount of water injection used, and the load which the engine is called upon to handle. If these conditions are all correct for heavy fuels, they are not correct for lighter fuels, and except for a small range in variation, they are not adjustable.

It is true that all of the troubles mentioned do not exist in all installations of such engines. In fact, some of these engines operate without any of these difficulties, but they have all taken place in numerous instances, and any and all may take place in any installation.

Present State of This Type

The success achieved by heavy fuels in this type of engine is due to a peculiar combination of some of the following conditions: The high price of gasoline with the consequent desire to handle a heavier fuel; a consequent response on the part of some manufacturers to build an engine which they can claim will burn the heaviest liquid fuels; the fact that a certain vaporization of these heavier fuels takes place when brought in contact with extremely high temperatures; that there is available in some localities certain grades of heavy liquid fuels at a low price; that these engines are simple in construction and simple in appearance; that they do operate on these fuels and deliver power, and in some instances to the expressed satisfaction of the owner; and that this engine is passing through a stage at the present time when its shortcomings are being excused, and the owners are loath to admit that any difficulties are being experienced.

This attitude is due to lack of information regarding the actual causes of difficulties; consequently, there is a tendency to consider the troubles as due to improper operation or some outside influence. Excessive cylinder wear, for instance, can be laid to soft metal or to improper attention on the part of the operator; cracked bulbs and choked exhaust ports may be blamed on the operator or the fuel used; and blown-off cylinder heads or cracked beds may be attributed to insufficient water injection or possibly defective material.

Proper Fuels

Specific gravity indicates little as to the vaporizing qualities of a fuel, although the majority of fuels above 38 to 39 deg. gravity vaporize readily and the majority below 35 or 36 deg. gravity do not vaporize readily. The flash point also tells little, as fuels with a heavy body may contain sufficient lighter constituents to show a flash at a low temperature. A definite indication of the quality, however, is the boiling point, or the temperature at which different percentages of the fuel will distill.

Vaporizing Type of Engine

Another reason why the heavy-oil engine has been brought into favor is the numerous published statements that the so-called gasoline engine is not adapted to handling kerosene and the lighter distillates successfully. While this has unfortunately been proven in some cases, yet in others the application of lighter distillates to the four-stroke-cycle vaporizing type has been successful.

There are many features in connection with the proper design of the vaporizing type for handling the lighter grades of distillate and kerosene. There seems to be a mistaken impression that the carburetor is the essential feature. While the carburetor should be properly designed there are other governing features equally important, such as piston speed, ratio of the stroke to bore, method of water circulation, location of the valves, shape of combustion space, location of igniter in combustion space, valve timing, voltage of ignition current, velocities through valves and intake passages, location of carburetor in relation to the inlet valve, contour of passages, governor valve and governor, method of automatically handling the mixture with varying loads, complete mechanical vaporization without resorting to preheating the charge, etc.

Engines Below 15 Horsepower

A large number of these small engines are used for farm work. They are usually of the four-stroke-cycle vaporizing type, using either gasoline or kerosene. The farmer should not attempt to use anything heavier than kerosene for this purpose. He should have an engine which is easily started, easily handled, and sure to run on a fuel which is readily obtained in small quantities.

It is doubtful if there is any other manufactured article which will vary to such a degree after it is assembled as will the gasoline engine. Pistons, piston rings and cylinders which are subjected to high temperatures and irregular distortion must be worn in together. Springs must be adjusted to the proper tension. Governors must be put in proper operating condition. Valve timing should be properly adjusted. Bearings should be worn in to avoid the possibility of their running hot. Brake tests should be made showing the engine developing its full rated horsepower. Water tests should be made of jacketed castings, as frequently leaks will develop after the engine has been in operation for some time. Moreover, the ignition system should be timed properly and checked up carefully. Considerable cost to the manufacturer can be saved by neglecting these matters, but the farmer should insist that the manufacturer produce an inspection sheet covering the detailed inspection and testing of the engine.

Conclusions

For many years after the internal-combustion engine came into general use, there was a current opinion that the engines were unreliable and tricky. This was brought about to a considerable extent by placing on the market a large number of engines which were not scientifically designed nor fully developed. It has taken many years of consistent effort to live down this prejudice.

We are now facing to a considerable extent a similar condition, because of the attempts to use heavy liquid fuels with a type of engine of cheap construction, such as has been heretofore described. Quite a large number of comparatively small manufacturers are experimenting with this proposition, with the result that undeveloped engines have been and are being placed on the market.

This type may in time achieve the results which it now claims, but in the meantime its failures should not be permitted to influence the industry as a whole. This can be accomplished best by a greater education of the public regarding the merits and demerits of the different types of engines, the different grades of fuel, and the purposes for which they can be used to the best advantage.

Small Marine Power Plant

By D. L. Roger

A small power plant, of interest because of its unique design and its economy in steam consumption, is shown in Figs. 1 and 2. This plant was installed in a 22-ft. launch and consists of a vertical boiler, vertical fore-and-aft compound engine and all necessary auxiliaries.

The engine has 3&6x4-in. cylinders and runs at a speed of 400 to 600 r.p.m. The boiler feed pump, air pump and fuel pump are driven by a drag crank and 2-to-1 gears from the forward end of the main shaft. The link on the low-pressure valve-gear is provided with an adjustment by which the receiver pressure is regulated. A reheater of U-shaped tubes connects the two cylinders.

The boiler is mounted aft of the engine. It is 12 in. high by 18 in. diameter and contains 426 half-inch tubes. The safety valve is set to blow at 200 lb. pressure. Kerosene is used as fuel in a special burner connected to a tank on which 70 lb. pressure is carried. The breeching carries the products of combustion through a superheater mounted on top of the boiler, around the high-pressure cylinder, through the reheater, around the low-pressure cylinder and to the atmosphere through a small stack mounted on the low-pressure cylinder.

Several tests have been made on the plant under working conditions on Lake Mendota, Wis. Numerous indicator diagrams have been taken of both cylinders and these show a steam distribution which is almost perfect. The engine consumes slightly less than 13 lb. of steam per brake horsepower-hour. The boiler, cylinders and

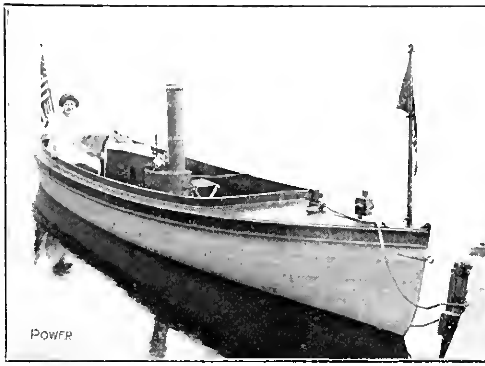


Fig. 2. Power Plant in Launch

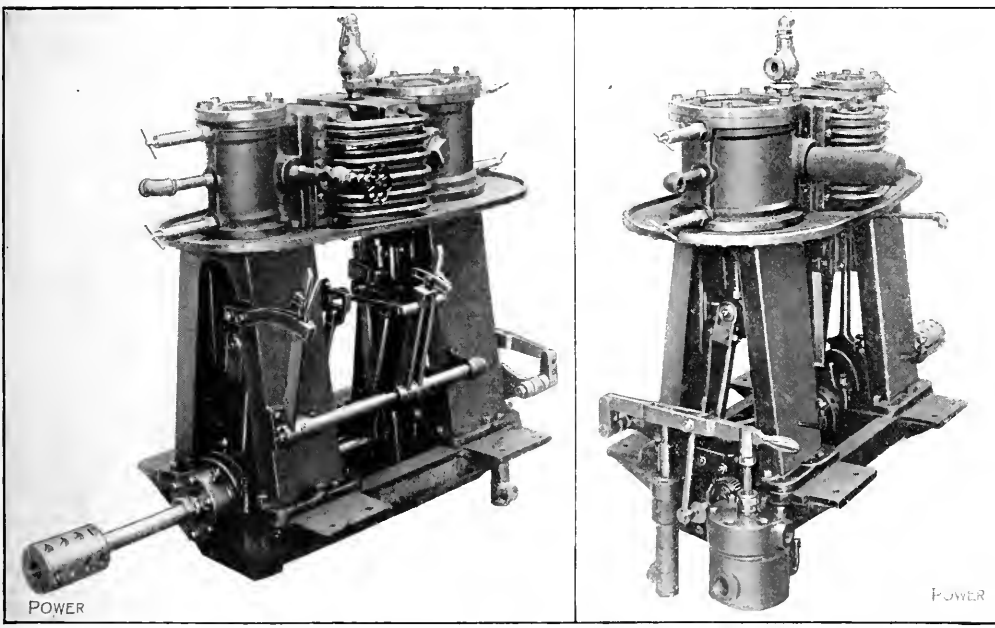


Fig. 1. Front and Rear of Compound Marine Engine

The steam from the boiler passes through a superheater, is expanded in the high-pressure cylinder, and is exhausted through the reheater to the low-pressure cylinder. After expanding in the low-pressure cylinder it exhausts into a keel condenser. The condensed water feeds the boiler. A filter is used through which the water is passed from the condenser overflow to the boiler-feed pump. The makeup water is also filtered.

breeching are so well insulated that it is possible to place the bare hand on any of these parts without discomfort. The gases escaping from the stack are exceptionally low in temperature.

J. C. White, chief engineer of the Capitol Power & Heat Co., Madison, Wis., designed and built this plant for his own pleasure. He started the work in 1909; the completed boat was put into the water in 1911.

Steam-Turbine Installation in Mexico

By John Klemm

For many years the Compañia Minera "Las Dos Estrellas" S. A., El Oro, Estado de Mexico, Mexico, has been purchasing its power from a public-service corporation. The slipping of one side of its greatest dam a few years ago seriously affected the power company for a time and caused heavy losses to innumerable customers. This company, being one of the several large consumers, in consequence installed a Westinghouse-Parsons multiple-expansion parallel-flow 1500-kw. steam turbine to generate three-phase current at 50 cycles and 3000 volts as a stand-by.

This turbine has a somewhat peculiar history. About two miles from the plant, in the center of a large masonry bridge, the trucks on one end of the car carrying the turbine broke down, precipitating the turbine to the river bed below, some 30 ft. Evidently, it did not wish to be installed at an 8000-ft. elevation. The machine was picked up uninjured except for a few paint scratches, and was installed and operated according to its specifications.

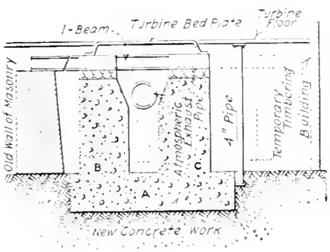


Fig. 1. Replacing a Turbine Foundation

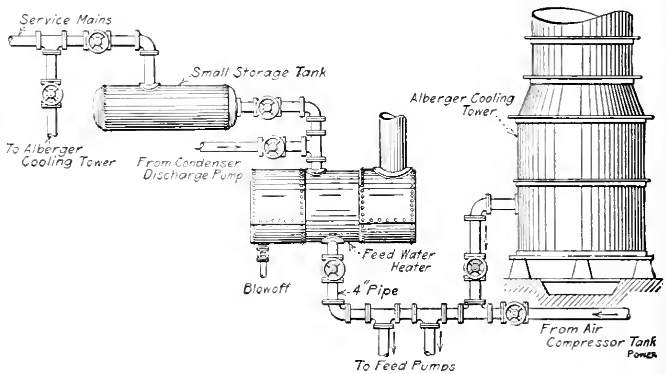


Fig. 2. Old Boiler Used as a Feed-Water Heater

Shortly after, the turbine wrecked itself so completely that an entire new spindle had to be purchased. Failure to start the auxiliary oil pump, unintelligent operation and weak masonry foundations, causing severe vibrations, were the causes, and conditions were made worse because of a 200-hp. compressor, operating on practically the same floor and foundation, whose vibrations caused a harmonic with the turbine vibrations. Another fault was that the I-beams were set directly on the masonry wall instead of being placed on some sort of material to distribute the weight; the I-beams thus sank into the masonry, and the machine, instead of resting on the entire length of the foundation wall, was practically where the I-beams had sunk.

At the time of the wreck, when the top half of the cylinder was raised someone remarked: "*Que buena ensalada*" ("What a fine salad"), adding the opinion that the most inefficient Corliss engine is far better than the most efficient steam turbine ever designed. This is a narrow-minded and prejudiced view, obviously untrue. The steam turbine has already proved its value, otherwise 30,000-kw. units would not be designed and operated, as they are today. Where intelligent and attentive labor is employed, there should be no chance for a steam turbine to wreck itself so completely as to require a new spindle. The turbine is not a very complicated piece of machinery; nevertheless, like any high-class apparatus it is not intended to stand abuse.

In this instance, to avoid further trouble it was decided to build a new foundation of concrete of the proportion 1 to 3 to 5, directly under the turbine, and do away with the masonry foundations, so designing the new work that the turbine would have absolutely no connection with the building or other apparatus, except the condenser, etc. The change was made with some difficulty, inasmuch as the machine had to be kept ready for immediate use in case of emergency.

From Fig. 1 an idea can be had of the conditions. The dotted lines show the temporary timbering. The space directly beneath the turbine, between the old masonry walls, was dug up and the concrete footing *A* laid. Wall *B* was built up to 5 in. below the 15-in. I-beam shown, and 12x12-in. and 8x8-in. timbering was placed between the new wall *B* and the old wall at *C*. This green timber was kept wet to prevent it from shrinking, so that the weight of the turbine could not come on the condenser. The old wall at *C* was then removed, a new concrete footing laid and the wall *C* built up and steamed to crystallize the cement, which was done in about 60 hr., thus avoiding the slow 28-day process.

For the steaming ½-in. pipe, previously drilled with ⅛-in. holes about 6 in. apart, was laid all around the bottom of the wall; the entire wall was then well covered with a heavy canvas and the steam turned on. At the beginning the temperature was held below 35 deg. C., then gradually increased to 70 deg. C., at which it was maintained for the last 12 hr. Great care must be taken not to overheat the concrete and thus ruin the entire work, especially if it is reinforced, as the coefficients of expansion for iron and concrete are different. The steam pressure never exceeded 1.5 atmospheres, and with this it was found that the best work was done on the top of the wall. After the steaming the electrical end was dried out before being placed in service, to avoid danger of a burnout.

Full-length 40-lb. steel rails were then placed on the new walls *B* and *C*, Fig. 1, and 1-in. plates and steel wedges set tight against the 15-in. I-beams on which rested the turbine bedplate. These rails served to distribute the weight of the machine over the entire length of the walls. All spaces between and around the rails and I-beams were then filled in with concrete to the level of the bedplate, making of the whole almost a solid box-like construction with the opening in the center. It may be criticized as inconsistent with uptodate construction not to allow more space below the unit, but this could not well be avoided, under the existing conditions; moreover, the space was sufficient, as all high-speed machines, especially turbo-generators, have artificial ventilation, cold air being blown into the windings. Without this precaution the air in the machine while it is running would be churned and would seriously affect the temperature rise.

The timbering was finally removed and the I-beams, one end of each of which was still in the old wall, were cut in a diagonal direction, as shown by Fig. 1, so that in settling, the I-beams could not again make contact with the old work, the tendency being to settle away.

An additional installation of three 400-hp. Babcock & Wilcox water-tube boilers brought the total boiler capacity up to 2400 hp. This addition may seem unnecessary, and, hence, a useless expenditure, but steam is always required for purposes other than power generation, and it is desirable to have ample margin for cleaning, etc. Further, it does away with the need for induced or forced draft and attendant loss of heat up the chimney, the extra cost of the apparatus and the disadvantages of boilers.

There are no peaks to consider; the load is steady throughout the 24 hr. The lighting load at night is hardly perceptible. The boiler feed water is taken almost directly from the condenser, a 4-in. pipe being tapped into the 12-in. discharge pipe of the circulating condenser pump (see Fig. 2). This 4-in. pipe discharges into an old fire-tube boiler used as a heater, and the water is then brought up to 90 deg. C. from the heater. It flows by gravity to the feed pumps, of which there are two Worthington 10x6x10-in. The pumps are also connected to the Alberger cooling tower and a tank, which is used to cool a 200-hp. Ingersoll-Rand compressor, so when the turbine is not in operation the boilers still get warm water. Steam is required for other purposes for 24 hr. daily, and is held for emergency. The heater is also connected to the company's service mains through a small storage tank above the heater, as Fig. 2 shows.

There are two wrought-iron expansion joints in the 8-in. steam header line, one U between what are known as No. 4 and No. 5 boilers, and a 90-deg. elbow between No. 1 boiler and the turbine. These suffice to take up any expansion in the header.

American fuel shipped to these regions comes high, costing on an average about $24.50, Mexican currency, per ton of 1000 kg. (2205 lb.) on the plant grounds.

The generator room is 39 ft. 8 in. by 89 ft., and is constructed of masonry. The doors and windows have a brick facing, presenting a neat and attractive appearance. The boiler room is 39 ft. 8 in. by 92 ft., and is constructed of the same class of material.

Coal Storage Tests—In his annual report as Chief of the Bureau of Steam Engineering, Admiral R. S. Griffin says: "The coal stored at New London under the three different conditions, in the open, under cover, and under water, was given the third annual evaporative test. No marked difference in evaporative efficiency was shown between the coal stored under different conditions, and no conclusive evidence developed as to the best method of storing coal."

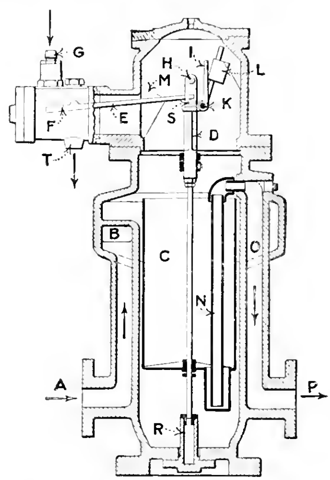
New Return Steam Trap

This trap is of the closed type, with the moving parts arranged inside the apparatus. It operates automatically when sufficient condensate has accumulated to move the float. It has few moving parts; therefore friction and wear are reduced to a minimum, and there are no stuffing-boxes.

The trap is made with a cast-iron body, brass inside parts and an open copper float. It is built for working pressures up to 180 lb. For higher pressures the body is made of steel.

In operation the condensate enters the trap at *A* and flows through opening *B* into the body. The water level inside of the apparatus rises until it reaches the top of the open float *C*, which is shown in its highest position. The float fills, loses its buoyancy and starts to sink, carrying with it the stem *D*, which pulls down on lever *E*. This lever, turning on the center *F*, opens the steam valve *G*.

As the float continues to sink, the roller *H* comes in contact with the short arm of the lever *I*, which, turning



Section through Return Steam Trap

about the center *K*, throws the attached counterweight *L* over to the left until the long arm of the lever presses on the roller *H*. The weight, falling over to *M*, will cause the roller, which is already in contact with the steam-valve lever *E*, to drop quickly. This gives a sudden increase in the opening of the steam valve, and the full pressure of the steam acts on the water in the trap, discharging it through the pipe *N*, the chamber *O* and the outlet *P*. A dashpot *R* takes up the shock caused by the counterweight falling on *M*.

A check valve on the inlet *A* prevents water from entering the intake pipes, and another in the discharge line prevents the return of the discharged water.

The empty float rising, throws the counterweight back to its original position and releases the lever *E*, allowing the steam valve to close. As the float continues to rise, the roller *S* lifts the lever *E* and opens the valve *T*, thus relieving the pressure in the trap. The steam which flows through this valve is received in a tank and condensed.

This trap is manufactured by the General Condenser Co., 1240 North 12th St., Philadelphia, Penn.

Why Direct-Current Motors Fail to Start—I

By F. A. Annett

SYNOPSIS—Directions for systematically locating the trouble, should a motor fail to start when the starting-box handle is thrown over.

When locating trouble in a motor, it is essential that certain features be given first consideration. Assume a case where the motor fails to start because of a blown fuse (f', Fig. 1). The first thing to ascertain in all such cases would be if the line is alive. This can be determined by connecting a lamp or voltmeter as at L. f', which may be removed and again tested, to make sure that a mistake has not been made in the test. This can be done as indicated in Fig. 3. If the fuse is blown, the lamp will not light.

If link fuses are used, the fact that they look good should not be taken as final, for a fuse may be broken off close to one of the terminals, and although it may look good on inspection, it is nevertheless open. Another point that should not be overlooked is the switch. One of the clips may be worn or sprung just enough to prevent it from touching the blade. Therefore, if the fuses

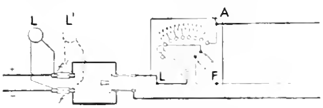


FIG. 1

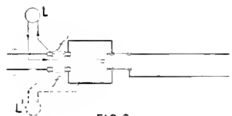


FIG 2

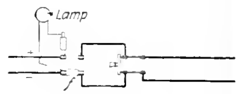


FIG. 3

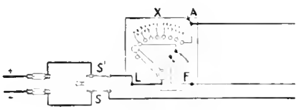


FIG 4

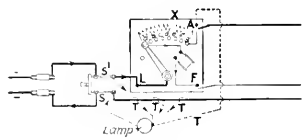


FIG. 5.

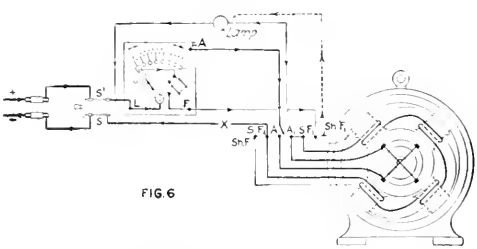


FIG. 6

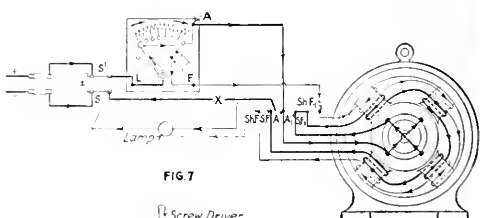


FIG. 7

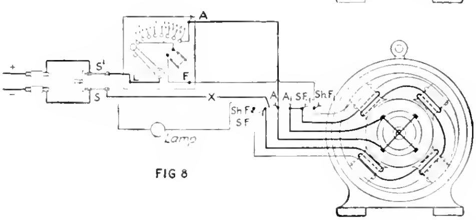


FIG 8

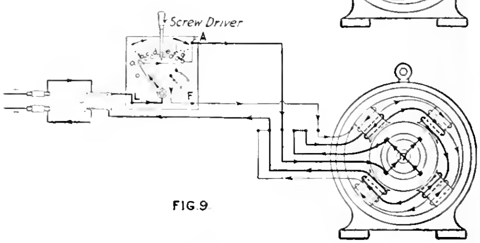


FIG. 9

How to Locate the Fault When the Motor Will Not Start

If the lamp lights, next test below the fuses as at L'. In this case it will not light, for the fuse f' is blown.

Most inclosed fuses indicate when they are blown, but this cannot always be relied upon, and when locating trouble the best policy is to depend upon nothing but what has been determined by test. To test the fuses without removing them, connect the lamp as illustrated in Fig. 2. If the lamp is connected as at L, it will light, indicating that fuse f is not defective. When connected as at L', it will not light, for the circuit is open in fuse test good, do not neglect to test the switch and see that the clips are making good contact and that none of the connecting wires are broken at the switch terminals.

If the break is in some part of the circuit other than the fuse, such as at X in the starting resistance, Fig. 4, an indication that the circuit is alive will be given when the starting arm is brought up to the first or second contact and allowed to drop back to the off position; that is, a spark will occur when the field circuit is opened.

If the motor does not start on the first or second contact point, bring the arm back to the off position and look for the cause. If it is loaded, first determine whether the load is free so that it can be started; also, that the motor bearings are not set on the armature shaft or worn so as to allow the armature to rub against the polepieces. The writer recalls an instance in which he was called in to repair a pump motor that another electrician had been working on all day, trying to get it to run. Upon attempting to turn the pump over by hand, it would not move, and the cause was traced to freezing of the pipe line running to the roof tank. There was nothing wrong with the motor or controller except what was caused by the ordeal they had been put through during the day.

After it has been determined that everything is favorable for the motor to run, the next thing is to make an inspection of all the electrical connections to see that they are tight and making good contact and that none of the wires are broken off at the connections; for sometimes a wire breaks off and will open only enough to interrupt the circuit, and unless it is moved it cannot be detected. If lugs are used on the wires, see that they are properly soldered, for if this has not been thoroughly done the wire will corrode in the connection and may cause an open circuit. All this is a hard and fast rule which may be applied to any motor whether direct- or alternating-current. Furthermore, it is well to make sure that the brushes are making good contact on the commutator and are free in the brush-holder pockets.

If the foregoing has failed to disclose the reason for the motor not starting, next test for purely electrical troubles. In this connection, first test the starting device. Fig. 5 shows a convenient way of doing this. Disconnect the armature and field connections on the starting-box and place the arm on the first contact, as shown. Then connect one lead of the test lamp to the switch terminal S (the one connecting directly to the motor), and to make sure that everything is in condition to make the test, connect the other lead T of the lamp to the other switch terminal S'. If the proper indication is had, next connect lead T to the "L" (line) connection on the starting-box. If the lamp continues to light, connect lead T to terminals A and F, as indicated, which in the present case will show a complete circuit through the starting-box to the terminal F, as indicated by the arrowheads, but not to terminal A, for the resistance is open at X. That is, when connected to F the lamp will light, but not when connected to A.

The exact location of the fault can be easily determined by testing to the contacts on the resistance. If lead T of the lamp is connected to contacts e, f or g, which are to the right of the break in the resistance, the lamp will not light, but when connected to d it will light. Since the lamp lights at d and not at e, it indicates that the circuit is open between these contacts.

A quick way to repair this fault is to drive a piece of fuse wire in between the contacts on the front of the slate between which the fault is located. A better and more permanent way is to remove the cover from the starting-box and repair the break in the resistance coil. If this cannot be located, as in some cases the coils are molded into a compound, the two contacts can be connected together on the back of the slate with a piece of wire.

In Fig. 6, X shows a break in the wire which connects the series and shunt fields direct to the switch. If the tests previously described are made and the circuit through the starting-box has been found complete, the next step will be to disconnect the two connecting wires between the motor and the starting-box, at the machine, and test through them as indicated. This will show a closed circuit, as represented by the arrowheads. Next connect the armature and field wires to their respective terminals and test through the armature and field coils, as in Fig. 7, and if they are not defective the lamps should light.

There is but one thing left to test and that is the connecting wire from the switch to the series and shunt field connections. To do this, connect one lead of the lamp to the switch terminal S' and the other to the end of the wire at the motor, as indicated in Fig. 8. In this case it will not light, which indicates that the circuit is open between the switch and the other end of the wire. The defect may then be definitely located and repaired, or the wire replaced by a new conductor. If the wires are in conduit or molding, the defective one should be replaced by a new wire, for a spliced wire in molding or conduit is a violation of the Board of Fire Underwriters' rules.

A practical way of testing for an open circuit in the starting resistance is illustrated in Fig. 9. Close the switch and bring the starting-box arm upon the first contact, and then bridge between the contact buttons with a piece of metal; a screwdriver being convenient for this purpose. If the break is in the starting resistance, such as between d and e, the motor will start when the defect is remedied; then the switch may be opened and the fault repaired, as previously explained.

An open circuit in the series field may be located as described in "Testing for Open Circuits in Field Coils," (POWER, Aug. 4, 1914).

Portable Boiler Exploded

This old boiler which the owner had recently purchased was being given a "tryout" on a wood saw. The engineer said the engine ran "snappy" with the throttle valve two

ENGINE'S POSITION AFTER EXPLOSION

turns open, which is taken as indicating that there was an excessively high pressure in the boiler, although the steam gage showed only 80 lb. and the safety valve was set, by the same gage, to blow at 100 lb.

The failure occurred at the bottom of the firebox, of the water-bottom type, where there was a section approximately 26 by 30 in. without stay-bolts. This section was forced upward, throwing the grate bars out through the fire-door. One section in its flight struck a dinner pail carried by a schoolboy, who was passing at a distance of about 200 ft., tearing it from the bail. The force of the explosion impelled the engine forward, nearly overturning it on the woodpile, as shown in the illustration. Two men were slightly injured.

Waste-Heat Boilers*

By Osborn Monnett†

SYNOPSIS—Smoke prevention in typical metallurgical furnaces operated in connection with waste-heat boilers. The latter are provided with independent furnaces.

Quite frequently the hot gases from metallurgical furnaces are available for steam making. When boilers are combined with such furnaces it is sometimes desirable to so arrange them that they may be fired by hand when the furnace is down. In this case provision for smokeless operation can be made by installing one of the hand-fired furnaces shown in previous articles. Care must be exercised in selecting a furnace adaptable to the particular type of boiler being used.

A typical installation is shown in Fig. 1. This boiler receives the waste gases from a billet-heating furnace, the gases coming through the perforated side walls of the setting. When this furnace is not in use the boiler can be fired by hand in the usual manner. As shown, the setting consists of a standard tile-roof furnace, with deflection arch, siphon steam jets and panel doors. Many metallurgical furnaces have underground breechings and it is generally simple to lead the gases to the boiler.

The underfeed type of stoker is especially adapted for the smokeless operation of metallurgical furnaces because it does not depend on natural draft for its air supply.

†Smoke inspector, City of Chicago.

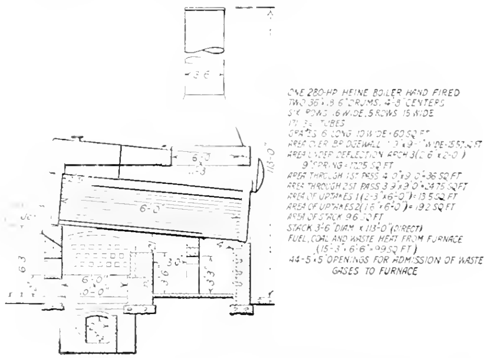


Fig. 1. Typical Waste-Heat Boiler Setting with Auxiliary Hand-Fired Furnace

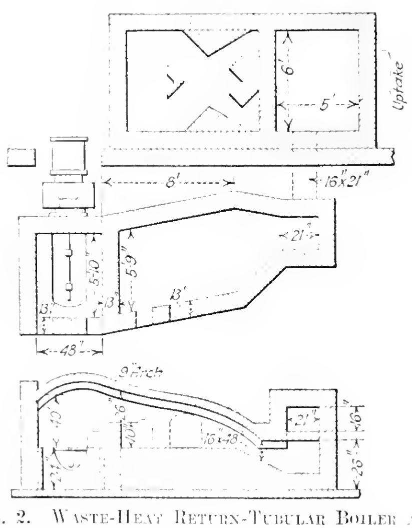


Fig. 2. Waste-Heat Return-Tubular Boiler and Forging Furnace with Underfeed Stoker

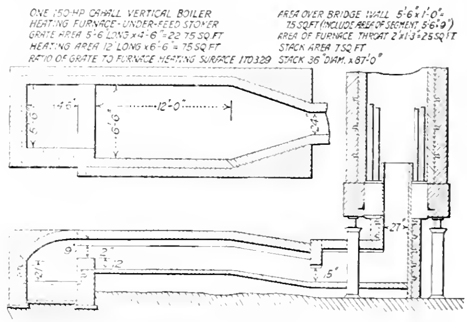


Fig. 3. American Underfeed Stoker and Heating Furnace Connected to 150-Hp. Cahall Vertical Waste-Heat Boiler

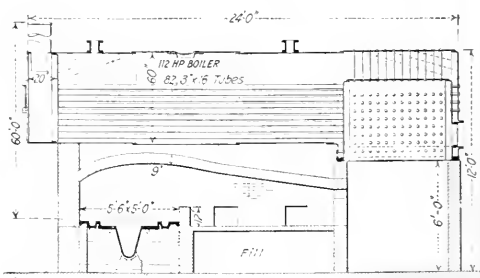


Fig. 4. American Underfeed Stoker and Forging Furnace with 112-Hp. Firebox Boiler

Owing to the length of the gas passes and number of turns, etc., there is generally but little suction over the fire from natural draft. Any stoker depending on natural draft and an ignition arch is at a big disadvantage from the standpoint of maintenance and capacity. An underfeed stoker will operate satisfactorily under conditions where a natural-draft stoker would burn up from the heat bottled in the furnace.

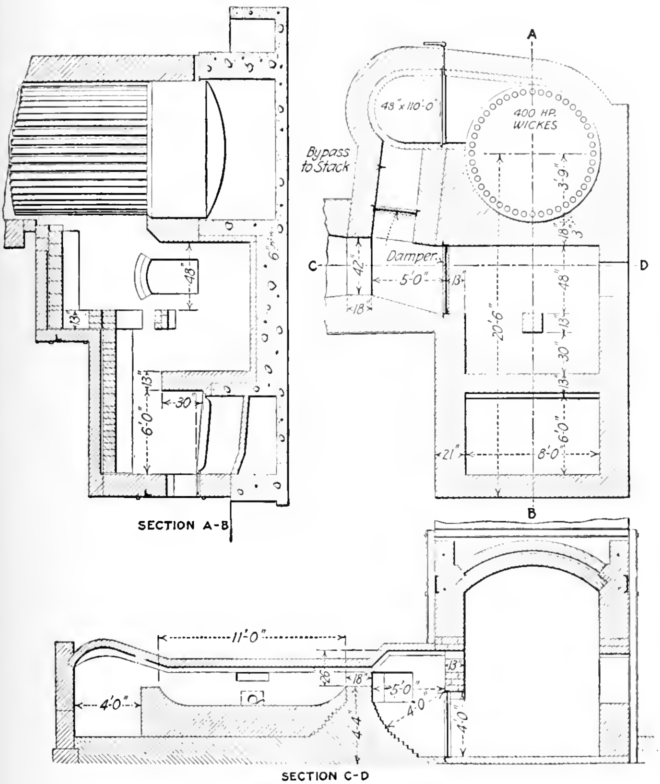


Fig. 5. Jones Underfeed Stoker and Malleable-Iron Melting Furnace with 400-Hp. Wickes Waste-Heat Boiler

Fig. 2 shows a waste-heat boiler of the horizontal return-tubular type installed in connection with a reheating furnace having an underfeed stoker. The boiler itself is equipped for hand firing, an ordinary No. 8 furnace containing a pier and wing walls being installed behind the bridge-wall. The usual rules for furnace areas based on the grate surface are allowed. If the boiler is to be used much, independently of the waste-heat furnace, the same stack height required by an independent boiler should be provided.

Another combination of metallurgical furnace and waste-heat boiler is shown in Fig. 3. In this case the ratio of grate to metallurgical heating surface is given as 1 to 3.29. The gases pass up through the lower drum of a specially constructed Cahall vertical boiler. Obviously, the proportions of the furnace depend on the product to be heated, so that the design must be varied to suit the conditions. The accompanying illustrations merely indicate how the different combinations can be operated without smoke.

Forging furnaces are often connected to waste-heat boilers, as the steam raised by the boilers can be used to advantage in the steam hammers, the same fuel sufficing for all operations in the shop. Fig. 4 shows an interesting and compact installation of this kind, consisting of a 112-hp. firebox boiler over a forging furnace fitted with an underfeed stoker.

When hand fired, the malleable-iron melting furnace produces a great deal of smoke. The underfeed stoker can be applied to this furnace with advantage and the waste heat used for steam making, as shown in Fig. 5. The latter consists of a 100-hp. Wickes waste-heat water-tube boiler attached to a melting furnace using an underfeed stoker and having an auxiliary hand-fired furnace for emergency purposes. With a bypass to the stack the melting furnace can be operated when the boiler is down for cleaning or repairs. Also, the furnace can be cut off from the boiler and the latter operated independently by closing the firebrick curtain-wall or damper, as indicated in the drawing. This makes a flexible combination. Another forging furnace with a Jones self-cleaning underfeed stoker is shown in Fig. 6, attached to a Wickes waste-heat boiler.

⁂

Belt-Driven Coal Crushers—The Edison Electric Illuminating Co., Brooklyn, N. Y., has found it advantageous to sacrifice plant efficiency obtained by using steam engines and to use motor drive with belt transmission for driving its coal crushers, as an obstruction in the crusher will either throw the belt or open the motor circuit-breaker instead of breaking parts of the crusher. Car couplings and pieces of steel frequently passed into the crusher with the coal, which stopped the rolls and the engine with a shock, thus subjecting the parts to excessive stresses. With belt drive the crusher and motor are protected against injury.

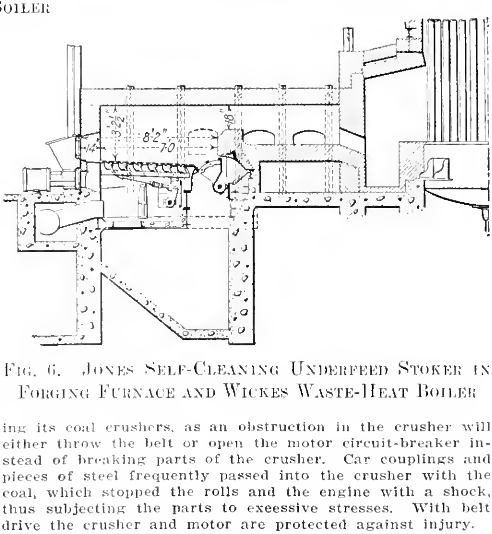


Fig. 6. Jones Self-Cleaning Underfeed Stoker in Forging Furnace and Wickes Waste-Heat Boiler

Selecting a Pump for General Service

By Charles L. Hubbard

SYNOPSIS—The article takes up briefly some of the more important points to be considered in the selection of a pump for general service in connection with power and industrial plants.

When the water is taken from the public mains or flows to the plant by gravity, the problem is simple and usually involves only the proportioning of pipes to the pressure and volume required. When the power house is at a higher elevation than the source of supply, the water must be pumped. If the conditions are such that the friction head in the suction pipe, plus the elevation, does not exceed fifteen to eighteen feet, the pumping equipment may be placed in the power house; otherwise, it must be located at some intermediate point where this limit will not be exceeded. Direct-acting steam pumps, engine- and turbine-driven plunger pumps and centrifugal pumps are adapted to the first of these conditions, and also to the last when the distance is not so great as to make the carrying of steam from the power house both expensive and wasteful. When the distance exceeds a certain limit it is usually better to drive the pump by an electric motor or gasoline engine than to install and care for a special boiler.

When the water is taken from a river, and the grades are suitable, a hydraulic ram may be employed where there is an abundance of water. This device is made in a large number of sizes and requires practically no attention, as the only parts subject to wear are the rubber valve-disks. With artesian wells there are two methods in common use for pumping the water. In the first, each well is equipped with a lift-pump driven by steam, electricity or gasoline, and connected with a common main leading to the power house. The second method makes use of the "air lift" and is especially adapted to cases where it is desirable to increase the flow and to plants using a series of wells, as one compressing outfit in the power house may be made to do the entire work.

Direct-Acting Steam Pump

This type is made in a variety of forms and sizes and is widely used for power-plant work. Piston pumps are adapted to locations where the water is free from grit or other substances likely to destroy the packing. When these are present, the plunger pump is preferable on account of the ease with which the worn parts may be repacked or renewed. One of the chief disadvantages of the direct-acting pump is its excessive steam consumption as compared with an engine or turbine, but this is offset in many cases by the low cost of installation, convenience and ease with which the speed may be regulated to meet varying requirements. Pumps of this type are made single, duplex, simple and compound, according to requirements.

Direct-acting pumps have an average mechanical efficiency of 65 to 75 per cent. and a "slippage" of 15 to 20 per cent. under ordinary conditions of adjustment. The steam consumption of small and medium duplex pumps will run from 80 to 160 lb. per developed horsepower, per hour, according to the size. By compounding, this may be reduced from 40 to 50 per cent. Pumps of this type are operated at a comparatively low speed, although the steam consumption per unit of work decreases as the speed increases. For large sizes the piston speed is usually limited to 100 ft. per minute, but for strokes of less than twelve or fourteen inches, the piston speed should be reduced proportionately. Pumps which are to run continuously should be designed to operate at about one-half the maximum allowable speed noted above.

Power Pumps

Power or geared pumps are used for practically the same purposes as the steam pumps just mentioned, but they are more economical to operate as they may be driven by an engine, turbine or motor. When belted to line shafting or driven by prime movers requiring a constant speed, they are not so desirable as the steam pump, owing to the difficulty of regulation. When used for supplying tanks and reservoirs or other purposes where they may be

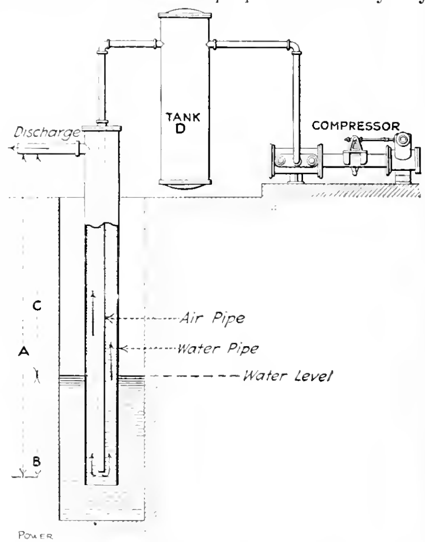


Fig. 1. Showing Principle of Air Lift

run at constant speed for long periods, they give satisfactory results and are supplanting the steam pump in many lines of service.

The efficiency of the triplex pump may be taken as about 60 per cent. for total heads of 100 ft., 70 per cent. for 200 ft., and 80 per cent. for 300 ft. The slippage is usually from 15 to 20 per cent.

Centrifugal Pumps

Pumps of this type have come into general use with the advent of the electric motor and the steam turbine. These are of two general forms, the "volute" and the "turbine," varying chiefly with the interior construction of the casing.

The volute pump is usually single-stage, and limited to heads of 100 to 120 ft., although two-stage machines are constructed for much higher pressures. Turbine pumps are designed for high lifts and are usually compounded in order to reduce the peripheral velocity and thus reduce the friction. It is important when using a centrifugal pump of any type to select one designed for the conditions under which it is to operate.

The efficiency of centrifugal pumps commonly runs from 60 to 80 per cent. for the better types, working under the conditions for which they were designed. The slippage varies from about 20 to 60 per cent., according to size and construction.

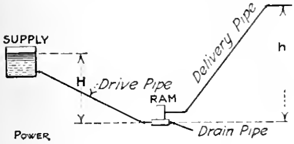


FIG. 2.

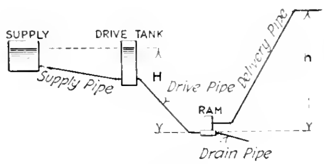


FIG. 3.

METHODS OF CONNECTING HYDRAULIC RAMS

Among the advantages of this pump are simplicity and compactness, absence of valves, low cost, uniform delivery and high rotative speed, adapting it to direct connection with motors and turbines. On the other hand, it is not possible to obtain as high an efficiency as with the best designs of piston pumps when the latter are kept in first-class condition. Furthermore, the speed cannot be varied, except within narrow limits, without loss of efficiency.

DEEP-WELL PUMPS

Deep wells are of two kinds—open wells having a large diameter, and driven or artesian wells. The type of equipment required in the first case consists of one or more pump cylinders placed within eighteen or twenty feet of the surface of the water and connected with some form of pump head at the top of the well by means of a long rod. The water is raised to the cylinder by suction and is then lifted or forced from this point to the surface of the ground.

With an artesian well an outer tube is driven to the required depth, extending to the surface of the ground. Inside of this, submerged in the water near the bottom, is the "barrel" containing the pump bucket and foot valve. The bucket or plunger is connected with a pump head at the top of the well by means of a wooden sucker rod, this material being used in order to reduce the weight. Pumps of this kind may be operated by a direct-acting steam cylinder or by a geared electric motor or a gasoline engine.

Deep-well pumps have an efficiency of 40 to 50 per cent. and a slippage of 10 to 15 per cent.

AIR LIFT

The principle of the air lift is shown in Fig. 1. A water pipe is carried down to the required depth, together with an air pipe either on the outside or the inside, as convenient. Compressed air is forced into the water pipe near the bottom, thus decreasing the density of the water within it, due to the air bubbles, and an upward flow is produced by the difference in weight between the column of solid water and the mixture of air and water. Air under sufficient pressure for raising the water is furnished by a compressor in the power house, the air pipe following the line of the water pipe.

The tank D is for equalizing the pressure and reducing the pulsation between the strokes. The distance B is called the "submergence," C the lift, and A the total head. In practical work the submergence is expressed as a percentage of the total head. For example, if A and B are 250 and 150 ft., respectively, the submergence is

$$\frac{150}{250} = 0.60$$

or 60 per cent. The efficiency of an air lift increases with the percentage of submergence and commonly runs from about 30 per cent. for

$$\frac{B}{A} = 0.5$$

up to 50 per cent. for

$$\frac{B}{A} = 0.8$$

A ratio of about 1 to 6 between the areas of the air and water pipes gives the best results for average conditions. If the air pipe is too large, power will be wasted in a high water velocity, and if too small, the air bubbles will not expand sufficiently to fill the discharge pipe, but will rise through the water without lifting it.

HYDRAULIC RAM

This offers the cheapest means of pumping where there is a sufficient supply of water and suitable grades.

Two general methods of connecting a hydraulic ram are shown in Figs. 2 and 3. If the drive pipe is too long, the excessive friction will interfere with the proper action of the ram, and if too short, water will be forced back into the drive tank. In practice it is customary to make the length of drive pipe equal approximately to the lift (h) to the tank or reservoir. When it is necessary, for any reason, to locate the ram at a greater distance from the source of supply, the required length of drive pipe can be secured by introducing a standpipe or intermediate drive tank nearer the ram, as shown in Fig. 3. For large quantities of water the fall from the source to the ram should not be less than two feet and, unless special provisions are made, should not in general exceed twelve or fifteen feet, owing to the shock when the flow is suddenly checked in the drive pipe.

Standard rams are made in large sizes, using from 400 to 15,000 gal. of water per minute (G), operating under a fall of 1½ to 50 ft., and raising water 35 ft. per foot of fall, up to a maximum of about 800 ft.

The working formulas for the hydraulic ram are as follows:

$$g = \frac{2 \times G \times H}{3 \times h}, \qquad G = \frac{3 \times h \times g}{2 \times H}$$

$$H = \frac{3 \times h \times G}{2 \times G}, \qquad h = \frac{2 \times G \times H}{3 \times g}$$

in which

g = Gallons discharged by ram;
G = Gallons required for operating the ram;
H = Fall, in feet, from source of supply to ram;
h = Height, in feet, to which water is lifted above the ram.

Chart for Coal Purchasers

By W. V. Bowles

Although coal is bought for evaporating water, few buy it on an evaporative basis. The reason usually given is that the human element or "error" cannot be accounted or compensated for. Most engineers agree that the evaporative basis is the correct one on which to buy coal.

Assume a plant which requires, say, 3000 or more tons of coal a year, and it is desired to purchase coal on an evaporative basis. The first thing to do is to run a test on the boilers with various coals and make a chart from the records obtained. The accompanying chart is plotted from a stoker plant and illustrates the idea and plan of procedure.

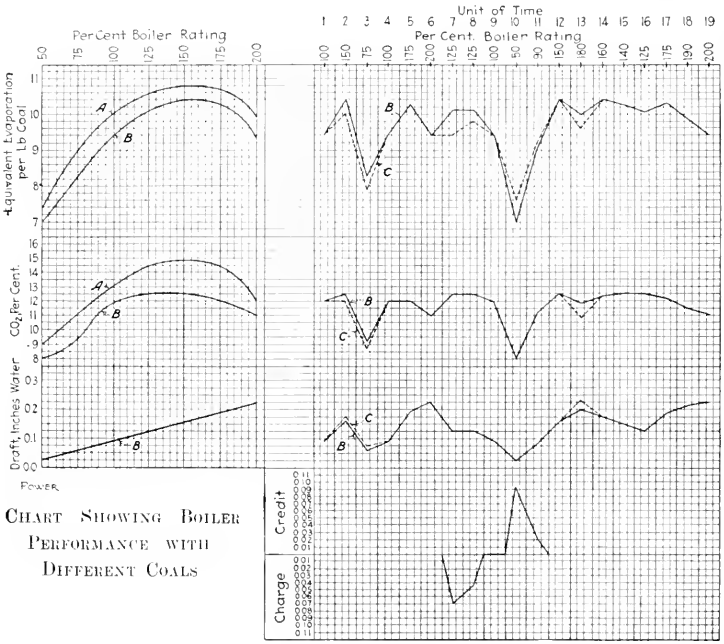


Chart Showing Boiler Performance with Different Coals

It is understood that the coal company should have a competent representative present during the test and at the calibration of all instruments and to have access to all records. First, the attainable evaporation and CO_2 curves are plotted at all boiler loads, together with a curve showing the best draft to use. Below is plotted a curve showing what is in the plant, termed "the adopted standard." This is based on a longer test when uncontrollable conditions may be taken into account.

The chart is also divided into a number of time periods, hours or days, as may be found most suitable. As each period is ended the average boiler rating is marked at the top, and below is plotted the adopted standard.

Referring to the charts under period 2, it is found that the average rating was 150 per cent. The equivalent evaporation should be 10.1 lb. per pound of coal, but the actual evaporation fell off to 10 lb. Following down the column, may be found the reason. The CO_2 dropped from 12½ to 12 per cent. Following still further down the column, the draft has increased from 0.16 to 0.175 in., showing the operating force to be at fault. A similar condition is indicated in the next column.

Under period 7 the evaporation dropped 0.069 per cent., but the operating conditions were according to adopted standards, when the coal company is penalized an equivalent of 0.069 on the coal burned during that period. If a better evaporation is gained than is shown by the standard line, as in period 10, the coal company is given a bonus equal to the increase; in this case, 0.092 per cent. If a shipment of bad coal comes in and the operating conditions are allowed to deviate from the standard, both will be shown in their correct proportion.

It may be found desirable to add draft lines to show conditions in other passes of the boiler, also temperature curves from the various passes. With proper checks on drafts, temperatures and CO_2, the human element can be accurately checked and accounted for; so there appears no good reason why the human element should control or influence the purchase of coal on an evaporative basis.

Such a chart should be an excellent thing to carry along from day to day for the benefit of the plant, even though it is not intended to buy fuel on this basis, for it will show the value of the firemen in dollars and cents.

Like all other kinds of record keeping these charts require much time to be made out. But in plants large enough to warrant checking of performances of apparatus a clerk is available who can plot curves from the tabular matter given him. Cross-section paper may be purchased that will fit nicely into large loose-leaf book covers.

Conditions Are Reversed in Making Gas—The steam engineer aims at minimum CO and maximum CO_2, while the gas producer engineer strives for maximum CO and minimum CO_2. A boiler works with a fuel bed usually varying in thickness from 3 to 12 in., whereas the depth of fuel bed in the producer varies from 2 to 10 ft. Maximum temperature in the furnace is the ambition of the fireman; on the other hand, a combustion zone of approximately 2000 deg. F., but varying with the nature of the fuel, gives the best results in the gas producer.

Philadelphia Municipal Lighting Plant—It is said that definite plans are being drawn up by the city of Philadelphia for the establishment of a municipal electric-lighting plant, which is to be ready to take over the lighting of the streets by 1916. It is understood that the plans of the Mayor, and Director of Public Works Cooke, contemplate the installation of a municipal electric plant at the old Spring Garden pumping station of the water-works, and the Keystone Telephone Co. has been asked for an option on the use of its underground conduits for the distribution system. The action was brought about by a recent decision of the State Public Service Commission, that a municipality has the right to establish a lighting system of its own without authority from the Commission, so long as it does not attempt commercial lighting.

Editorials

Engineers' Wages

Quite a few letters commenting on Mr. Pagett's article on this subject in the January fifth issue have been received, for the subject, broadly, is of interest. Nothing new or valuable is contained in these letters and for this reason we do not publish them. The writers, with few exceptions, recognize the fact that local conditions vary so widely that one should not expect to find a uniform wage over several sections of the country. These letters reflect the good judgment of power-plant men by claiming that it is right that there is no wage standard among engineers. The very nature of the service precludes such a thing if equity to all is to be had.

If an engineer's duties consisted chiefly of a few movements, physical or mental, if there were even a remote possibility of "Taylorizing" him, if there were a semblance of standardization about his routine, then well enough to talk about a standard wage. But these things cannot be. The individual's service is the only true measure of his worth.

Coal-Saving (?) Dope

There seems to be an epidemic of coal-savers on the market—not methods and apparatus for saving coal in a legitimate way, but nostrums which, sprinkled upon the coal, are claimed to greatly intensify its calorific value or at least the efficiency with which it can be burned.

As the rustic visitor to the circus said of the giraffe, "There ain't no such animal." And even as the rustic said it in the actual presence of the beast, we reiterate it in the face of claims of results produced and testimonials to savings supposed to have been accomplished.

There is no substance known to man which, sprinkled upon coal, will make it evaporate more additional water than the extra coal which the price of the dope would have bought could generate. Let us make a slight reservation. There are some coals which, thrown upon the fire, will immediately disengage a lot of volatiles like a bunch of kerosene-soaked waste. A little water sprinkled upon such coal will retard this action and perhaps save enough in volatiles which would otherwise escape, to more than offset the loss of the heat required to evaporate the water. But the action is as described and not due, as is often claimed, to the combustion of the decomposed water; for it takes just as much heat to decompose the water as it generates in getting together again.

We got caught once with one of these concoctions. We told the promoter that if he would have a test made of it by a competent and reputable engineer, and if it showed a material saving, we would publish the test and proclaim the results. He let us choose the authority, and to our astonishment the test showed from seven to sixteen per cent. better evaporation with the dope than without it.

The files of POWER will show that we carried out our promise; but even with the treated coal the evaporation was only six and a half to seven pounds, and a very little difference in manipulation would account for the bringing of a wretched performance up to this not much better one. That our skepticism was warranted is shown by the fact that the stuff was never able to hold its place upon the market.

This was many years ago. Before and since, many compounds for the same purpose have been hawked about, found a few victims and passed away. We have analyzed and exposed several of them. If they were any good, they would be in universal use now. Do not spend good money for them and be made ridiculous without something better than a salesman's claims or a lot of questionable testimonials to fall back upon when the inevitable failure comes.

Uniflow or Una-flow

The German term *Gleichstrom* (*gleich* = even, same; *Strom* = stream, current) used by German electricians for "continuous current" applies naturally to the continuous or unidirectional flow of the steam in the central-exhaust engine, reinvented and made a success by Professor Stumpf; and in German this is known as the *gleichstrom* engine. The English equivalent, unidirectional-flow, is cumbersome and soon became contracted to "uniflow." When the English translation of Professor Stumpf's book upon the engine appeared it bore the title "The Una-flow Engine." Curious as to the reason for this variation, we wrote to Professor Stumpf and to the translator.

Professor Stumpf says: "After considerable correspondence between Mr. Alexander and myself we decided upon the name 'Una-flow.' This is a little in line with, for instance, contra-flow condenser, and should be better than 'Uni-flow.' I prefer to use the hyphen, but this is a matter of taste. Uni-directional-flow engine was our first name, but we found it to be too long. Nobody would say contra-directional-flow condenser. Therefore we dropped this name and replaced it by 'Una-flow.'"

Mr. Peter S. H. Alexander, the translator of the book, says in reply: "The full term which was used by Professor Stumpf and myself was originally uni-directional-flow. When the book was fully prepared for the press in England, the English licensees, Messrs. Musgrave, had already issued a circular in which they had described it as the 'Una-flow.' In view of this, after some little discussion, it was decided, in deference to the new christening of Messrs. Musgrave, that the title of the book should be 'The Una-flow Engine.' If a short title is to be preferred to the full title of uni-directional-flow, I should say that 'Uniflow' in one word would be the best, from the point of view of everyday language. I am exceedingly sorry that there is not a more subtle or logical reason for calling the engine by the name 'Una-flow.'"

We quite agree with the translator. The English prefix for one is uni, not una. The prefix for counter or against is contra, but it is just as logical to signify the unidirectional flow of the steam in the central-ported engine by "Una-flow," in an attempted analogy with contra-flow, as it would be to speak of the contri-flow condenser, in a forced attempt to be consistent with the other prefix.

We apprehend that Professor Stumpf knows more about inventing and designing the engine than he does about coining an English name for it, and are afraid that we cannot follow his lead in this respect, although we were inclined to adopt the spelling proposed by the man who is responsible for the success of the engine itself.

Formulas for Bumped Heads

At a recent hearing of the Massachusetts Board of Boiler Rules, it was shown that a number of the changes proposed by the board and which were considered at this hearing, were not intended as they were written. An engineer of national prominence who was present suggested that it would be well for the board to employ an engineering editor to draft such changes or additions to the rules as might be desired, so that the intent of the board would be expressed by the rules as written. The Air Tank regulations, just issued by the Board of Boiler Rules, is another evidence that the advice of this engineer was good. It is difficult to express just what is intended unless one is a master of the English language, and especially is this so when technical subjects are treated.

In the Air Tank regulations that were adopted under date of December 16, 1913, the rules were intended to be very specific as regards the calculation of the strength of bumped heads, and were drawn up as follows:

BUMPED HEADS

11. The minimum thickness of a convex head, convex to pressure, shall be determined by the following formula:

$$\frac{R \times F.S. \times P}{T.S.} = t$$

The minimum thickness of a concave head, concave to pressure, shall be determined by the following formula:

$$\frac{R \times F.S \times P}{0.6\ (T.S.)} = t$$

R = One-half the radius to which the head is bumped;
F.S. = 5 = factor of safety;
P = Working pressure, in pounds per square inch, for which the tank is designed;
T.S. = Tensile strength, in pounds per square inch, stamped on the head by the manufacturer;
t = Thickness of head in inches.

It was unfortunate that a convexed head was referred to as one convexed to pressure, because this was contrary to the generally accepted idea on the subject; but this would not have been an insurmountable difficulty if it had not happened that the formulas were somehow reversed as applied to the two forms of heads, resulting in a higher pressure being allowed on a head which was convexed to pressure than on one concaved to pressure, as will be seen by noting the formulas given.

Soon after the publication of this set of rules, it was found that they contained a number of errors and the rules were never rigidly enforced; but the present issue was prepared after a new act of the legislature, and it was anticipated that the previous errors would be corrected. The present Air Tank rules were approved by the Board on August 12, 1914, and the subject of bumped heads was treated as follows:

BUMPED HEADS

Convex Head, Curved Outward from the Shell

12. The minimum thickness of a convex head for riveted or forged welded shells shall be

$$t = \frac{8\tfrac{1}{3}\ R\ P}{S}$$

except that the least thickness shall be 3/8 in. on tanks 20 in. in diameter or larger, and 5/16 in. on tanks of less than 20 in. diameter.

The minimum thickness of a convex head for seamless cylinders shall be

$$t = \frac{5\ R\ P}{S}$$

except that the least thickness shall be 1/4 in.

Concave Head, Curved Inward to the Shell

The minimum thickness of a concave head shall be

$$t_1 = 1.67\ t$$

where

t = Thickness, in inches, of a convex head;
P = Working pressure, in pounds per square inch, for which the tank is designed;
R = Radius, in inches = 1/2 the inside diameter of the outside course of the shell;
S = Tensile strength of the shell plates, in pounds per square inch;
t_1 = Thickness of a concave head, in inches.

Convex and concave heads shall be dished to a radius equal to or less than the diameter of the shell, and shall be true portions of spheres.

The description of a convex head defines what is intended and the formula given is correct as far as the evident intent to increase the safety factor on such heads is concerned; but in calculating the strength of a convex head there is no occasion to involve the tensile strength of the material of the *shell* plates of the vessel to which it is attached. That the Board of Boiler Rules believed that there was some connection between these two or that it has made the mistake of improperly expressing itself, is evident from the definition of *S*.

It will be seen, too, that an error has been made in the definition of *R*. If *R* had been stated as equal to one-half the radius in inches or, more correctly, as equal to one-half the radius to which the head was bumped, in inches, without any further additions, the formula would have been correct as far as the calculation of the strength of a bumped head was concerned. However, allowing that this error is a possible mistake of the printer, the matter is still not cleared up with the added information as given in the rule, for it will be noted that the sentence immediately below the definitions of the letters used in the formulas does not coincide with the definition of *R*. The sentence referred to provides for any radius for a bumped head which does not exceed the diameter of the shell to which the head is attached, while the definition of *R* would preclude the use of any radius which would not equal the radius of the shell to which the head was attached. It will be seen that if the rule must be literally followed as written, only a hemispherical head will be acceptable, and the value of *t* as found by the formula, will be twice as great as was really intended.

As stated in the beginning, it is difficult to write rules so that they will express just what is intended, but the employment of an experienced editor to review the rules before their publication would have avoided the errors here pointed out and would have been a real economy to the State of Massachusetts.

In every plant and factory some sort of an emergency first-aid-to-the-injured kit should be provided. A modest and yet complete one is that described on page 185, adopted as standard by the Conference Board of Safety and Sanitation. As this outfit is sold without profit, we are free to recommend it most heartily.

Correspondence

A Correction

In the issue of Jan. 5 I note in the article by Norman G. Meade, "Electromagnets for Alternating-Current Circuits," in the calculation of the magnet to work on 25 cycles, that the line voltage is taken at 440 volts. In figuring the formula for turns (T) the value 1468 turns is the number required for the entire core, or the 440 volts, and not for one coil, as stated. The computations then should be as follows:

$$Turns\ per\ spool = \frac{1468}{2} = 734$$

The ampere-turns as stated in the article are 3150 per spool. Therefore, the amperes would be $\frac{3150}{734} = 4.3$. At 2000 circ.mils per ampere this figures 8600 circ.mils. The nearest wire to this size is No. 11 B. & S., which has an area of 8234 circ.mils.

From the table given in the article, No. 11 wire has 9.7 turns per inch and, allowing 8½ in. for the length of the spool, gives 82.5 turns per layer: $\frac{734}{82.5}$ is approximately 9 layers. Assuming that the layers and the insulation between them measure 1.5 in., the length of a mean turn will be 18 in. and

$$\frac{734 \times 18}{12} = 1100\ ft.\ per\ spool$$

or 2200 ft. as the total length.

No. 11 wire has a resistance of 1.25 ohms per 1000 ft., or for the coil of 2200 ft. the resistance would be $2.2 \times 1.25 = 2.75$ ohms. Then the I^2R loss equals $4.3 \times 4.3 \times 2.75 = 50.9$ watts. The hysteresis and eddy current losses will not change and the total loss in watts will be $50.9 + 41.4 + 10 = 102.3$ watts.

W. O. Jacobi.

Omaha, Neb.

Peculiar Gas-Engine Accident

After studying over the account of the gas-engine accident as reported in the Dec. 29 issue, page 935, I cannot see how the engine could have been wrecked in any other way than by preignition or a continued too early ignition, which can readily develop from the use of a hot tube. The jacket water becoming very hot and heat radiating up around the tube guard, the flame around the tube, being better guarded, would increase in temperature. This would heat the tube to a whiter heat, which would ignite the gas at a lower compression; also, the cylinder being hot, the gas would reach a higher temperature in an earlier stage of the compression. Continued early ignition would put an unusual strain upon the housing or bedplate, and it may have been gradually fractured until one very early preignition caused it to give away.

The conditions do not indicate that the break was caused by water. In the first place, the clearance of a gas engine is nearly 20 per cent., or one-fifth the volume of the cylinder. Using illuminating gas, it is probable that the mixture was about one to eight and not lower than one to six; therefore, the gas volume of any charge would be less than the volume of the clearance. Consequently, the gas opening to the cylinder would probably not pass at any one stroke a larger volume of water than that of the gas, so that it would be impossible for enough water to pass into the cylinder in one stroke to more than fill the clearance. Moreover, if there had been enough water in the gas line to fill the opening at any one time, the gas flow previously would have been so reduced that the engine would have stopped or operated irregularly. Again, if small quantities of water had been coming over, before enough water had accumulated to interfere with the piston the cooling effect and moisture would have "killed" the hot tube, so that the engine would have continued to miss fire and stop.

The resulting condition of the engine would indicate an explosive break rather than a water break. In the latter event the strain would not have reached the breaking point until the piston was nearly in the center, in which case the breaking strain would have been in almost a straight line and the engine would not have buckled upward very much. With preignition, the break might have resulted while the piston was two-thirds or three-quarters of the way to the head center, which would leave the crank at a low angle and the strain upward. This would have the tendency to throw the shaft end forward and the cylinder upward, and the still expanding gas of the explosion would blow the piston clear out of the cylinder and upward, where it afterward fell back on top of the cylinder. If the force of the explosion had been a little greater, no doubt the piston would have been found lying on the floor in front of the engine.

L. M. Johnson.

Emsworth, Penn.

A personal inspection of this engine might disclose some peculiar reason for this accident, but if I understand the nature of the accident, one does not have to look far for the cause. It is stated that the bedplate cracked square across, and if that means a crack extending roughly in a vertical direction from a point on the frame just back of the main bearings to the bottom of the frame, the cause would seem to have been faulty design. The forces acting are exerted in a line coincident with or parallel to the engine axis, and yet, in this type of engine the metal through which the total force of each explosion reacts (the frame) is placed some distance below this axial line. The resulting action may be compared to the process of breaking a chicken's wishbone by pulling on the ends. The frame must stand a much greater stress than if the metal were placed symmetrically about the center line, and many builders do not seem to appreciate this fact sufficiently to induce them to put enough metal in the frame.

A better method is to design the frame so that the reaction is taken up by metal distributed about the line of action (the forces transmitted through the piston rod and connecting-rod); builders of large gas engines would not dare build them with any other type of frame.

Every explosion, in the type of engine illustrated, is a force tending to open up the frame in exactly the place and manner in which it evidently let go, and the intermittent application of such a force is very apt to have the observed effect in time.

The writer has seen a number of accidents of this very kind in this type. The peculiar circumstance was the position of the piston after the accident and the fact that the frame settled back into place. The rear end of the frame, together with the cylinder, usually makes a rapid rearward journey until stopped by something solid.

L. B. Lent.

Brewster, N. Y.

The break would seem to have been caused by a premature ignition. This is a common occurrence with hot-tube ignition, causing beds to break unless made extra heavy. It was only a short time ago that the writer saw a new 50-hp. engine bed break from this very cause.

G. Strom.

Titusville, Penn.

The accident was probably caused by water in the cylinder or preignition, as stated. Personally, I favor the preignition theory, as the hot tube is quite liable to vary the time of ignition—more so than the mechanically timed electrical system; or the charge may have preignited because of incandescent carbon in the cylinders, overheating, etc. It doesn't seem that enough water could have been drawn into the cylinders from the gas line to have caused any damage, as only a small part of the charge is gas.

Forrest R. Carpenter.

Salmon Falls, N. H.

Comment on Ammonia Diagrams

I note in your Dec. 29 issue, page 930, two articles on ammonia-compressor diagrams. The first, by Charles Mugler, does not give the clearance of the compressor either in per cent. of displacement or in per cent. of the crank-end and head-end volumes. This information should be given, as otherwise it is impossible to judge whether or not the compression obtained is that for a machine in good condition. The compression curves just after the suction valves have closed seem to show an unusual increase in pressure, which may be due to piston leakage, but without knowing the clearance of the compressor it is impossible to draw correct adiabatic curves on these diagrams. If the diagrams are drawn to scale, the pressure at the end of suction for both ends of the compressor is about 19 lb., whereas for a compressor with properly designed suction valves the pressure at this point should be higher than the pressure recorded on the suction gage. This is due to the inertia of the vapor in the suction pipe which keeps the valves open even after the piston has reached the end of the stroke. The excessively high discharge pressure, even after the discharge valves are open, indicates that either the ammonia condenser to which this machine is connected is too small, or the discharge pipe too small in diameter for its length.

The fact that there is a hook at the end of the expansion line of the right-hand diagram, and not one on the left-hand one, shows that the suction valve on the right-hand end of the machine either sticks or is provided with a stronger spring than the one on the left-hand end.

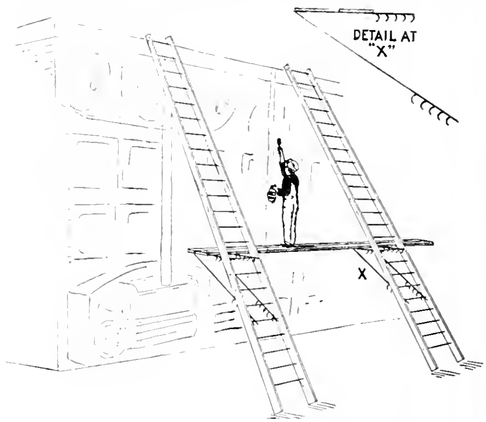
In regard to D. H. Crawford's discussion of the ammonia-compressor diagram, I do not agree with his explanation of the broken-line discharge curve *BCDE* (Dec. 29). Whenever an ammonia-compressor diagram is taken with a rather weak indicator spring, these zigzag lines are frequently noticed and are generally caused by the momentum acquired by the indicator piston from the rapid rise of pressure in the compressor near the end of the compression stroke, and seldom by the chattering of the discharge valve.

Fred Ophüls.

New York City.

Handy Staging

The illustration shows a handy staging for use when working on shafting, pulleys, the fronts of boilers, etc.



One Application of the Staging

Any handy man can make and attach it to a couple of ladders without difficulty.

Thomas Sheehan.

Williamstown, Mass.

Feed-Water Heaters

In the issue of Oct. 13, page 540, L. B. Carl commented on the relative merits of open and closed feed-water heaters.

The writer, having had considerable experience with feed-water heaters, begs to call attention to one statement made therein as follows: "A closed heater is not suitable, where the exhaust steam is intermittent, because the sudden changes in temperature will loosen the tubes." This is true of the straight-tube type only, and where proper provision is not made to allow for the unequal expansion of the shell and tubes.

I believe the best heater for resisting the effect of sudden temperature changes is the coil type when properly designed and built, as it will operate for any number of years without any of the joints becoming loosened, due to expansion and contraction. All the joints should be brazed, as these are best able to stand the boiler pressure and sudden temperature changes.

W. C. Beekley.

Hartford, Conn.

The Night Engineer Off Duty

The editorial in Power, Oct. 13, 1914, entitled "The Night Engineer Off Duty" was certainly appreciated by me, for I spent three years on the night turn.

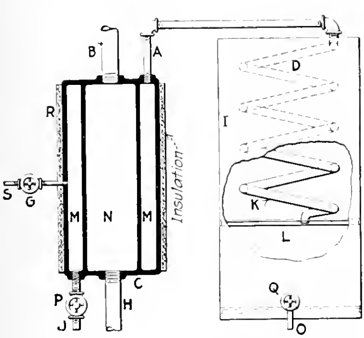
It calls to my mind a little incident of Yankee ingenuity. Several years ago, while erecting an ice plant in the South, I visited the factory one night to see how the machine was running, for we had just started and I was on the lookout for trouble. I found the old man who had the night turn sitting in a chair, holding a 12-in. monkey-wrench in his hand. As he did not seem to be using it, I asked why he was holding it, and this was the answer: It had been too hot that day to sleep much and he was sleepy. If he went to sleep he would loosen his hold on the wrench, it would fall to the floor and awaken him. He would then get up and take a look around the engine room, sit down and pick up his monkey-wrench alarm and take another rest.

Perry Losh.

Muncie, Ind.

Practical Use for Gas-Engine Exhaust

The sketch shows a water-distilling apparatus operated by the waste heat in the exhaust gases from an internal-combustion engine. It is adapted to power houses, factories and boats where pure water for drinking and other purposes is desired.



Section through Distilling Apparatus

The apparatus consists of a cast-iron drum C divided into two separate compartments N and M, a heat-insulating cover R, a cooling tank D divided into two separate compartments I and L, and a condensing coil K.

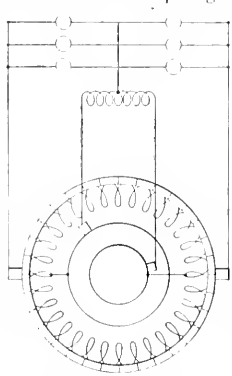
The exhaust gas from the engine enters the drum C through the pipe H, fills the chamber N, and passes out the pipe B. Water enters the compartment M, through the pipe S, regulated by the valve G, is vaporized from the heat in compartment N, passes through the pipe A into the condensing coil K, surrounded by cold water in the tank I, is condensed, and flows into the reservoir L, whence it is obtained from the faucet Q. The residue from the distilled water is run off through the pipe J, controlled by the valve P.

F. B. Hayes.

Houston, Tex.

Flickering Lights

The sketch shows the connections of a three-wire generator. For simplicity it is shown with two poles, although four or more are usual. The armature generates 220 volts, obtainable from the outside wires connected to the brushes. Two slip-rings mounted upon the armature shaft are connected at diametrically opposite points of the armature winding, and from brushes bearing upon the slip-rings conductors are carried to the ends of an iron-cored reactance coil, to the center of which is connected the middle or neutral wire of the three-wire system. A resistance might be used for this purpose, but as the device is continuously subjected to alternating e.m.f., reactance is more effective in limiting its value.



Connections of Three-Wire Generator

The net result of the arrangement is that 220-volt motors may be operated from the outside wires and 110-volt lamps from either outside wire and the neutral. The reactance carries direct current only when the two sides of the service are unbalanced. The unbalancing direct current entering the reactance at the center divides, half flowing around the core in one direction and half in the other; its magnetizing effect is, therefore, practically nothing.

An inspector was called to find out why the lamps fed by such a unit flickered. Inspection of the taps from the rings to the winding disclosed that they were not tapped to the winding at equidistant points. Changing the taps to points of symmetry stopped all flickering.

J. A. Horton.

Schenectady, N. Y.

Drains above Back-Pressure Valves

A drain should be connected just above the back-pressure valve. If connected at a higher point, the vapor may condense and create a static head above the valve, which will prevent it opening under ordinary pressure.

The vent pipe may be dispensed with by drilling small holes in the seat of the back-pressure valve. The escape through these openings will be sufficient to relieve air-binding in the heater and drain back any condensation in the exhaust or vapor pipe.

T. W. Reynolds.

New York City.

Unsafe Blowoff Piping

A couple of years ago I was a fireman and assistant in a small cold-storage plant. There were three boilers, but we only fired one, which was sufficient to carry the load. The night fireman asked me to do all the blowing down on No. 2 boiler, as its blowoff valve was situated so far back in a dark corner that if anything should happen he wouldn't have as good a chance to get out in the dark as I would in daylight.

I did so until one day the boiler inspector told us to disconnect No. 2 blowoff, as he did not believe the pipe between the valve and boiler was made up very tight. You may imagine our surprise to see it drop out of the elbow near the boiler after giving it only a half turn when unscrewing it. The pipe had only two threads caught, and they were nearly eaten out. The steam fitters had cut it too short, but used it anyway to save cutting another. I learned afterward that the night fireman knew of this, hence his distaste for blowing down this boiler.

C. KNOWLAND.

Louisville, Ky.

Why the Gage Hand Vibrated

The cause of the gage hand vibrating, as referred to by A. E. Aldrich in the Jan. 5 issue, was the intermittent steam flow caused by the cutoff of the reciprocating engines. During the daily periods referred to there was some change in conditions, as an additional unit in service or *vice versa*. The oiler in turning the valve simply closed it a little more than usual, which should have been done before.

JOHN F. HURST.

Louisville, Ky.

Cost of Operating Vacuum Ash-Handling Systems

The discussions of vacuum ash-removal systems in the July 7, Sept. 8 and 15, and Oct. 20 issues, following the article describing the Girtanner-Daviess system in the April 7 number, have been both interesting and fair-minded and have brought out a number of instructive features. The point is to be emphasized, however, that the instances of expensive installation and heavy repairs cited do not refer to the system described in the original article, as the discussions refer to motor and blower costs instead of a steam jet. Even Mr. Sandstrom's estimate of charges in the July 7 number is based on his experience with a blower system.

The absolute cost per ton of ashes removed has no comparative value as a criterion. The most economical system, from wheelbarrow up, for an unfavorable location, may still leave costs high. Furthermore, the final receiving tank may be ignored for purely comparative costs of different systems (unless special expense is here necessitated by the peculiarities of a system) since such tank should rather be imposed equally on each system by the final disposition made of the ashes. This system will discharge directly onto a dump or into any receptacle.

The maximum repair bill for a year on steam-jet installations ranging in price, for pipe line only, from a few hundred up to $1100 has been a fraction over $32—about one-seventeenth of the 40 per cent. experience of Mr. Sandstrom. Again, one man is well able to handle the seven tons per hour for which Mr. Sandstrom wishes to hire two, and this cuts his labor cost in half. In moderate-sized plants the system may be operated by the fireman along with his other duties, and in larger plants the attendance is a minimum. The initial cost is low, so that interest on the investment does not eat up economies secured. The steam used in the jet amounts to 5.29c. per ton (see Apr. 7 POWER).

GIRTANNER-DAVIESS.

St. Louis, Mo.

Finding the Best Coal

The letter, "Finding the Value of Coal," by William A. Dunkley, in the Jan. 5 issue, interested me. One point of importance was not stated in the article, and that is, whether the coals furnished by the roads A and B were of sensibly the same character. If the fuel tests of the two coals showed wide variations in ash, volatile, sulphur and heat, trouble in the fire-room could have been predicted in advance of the change from one coal to the other, provided no change was to be made in the method of handling the fires.

The following quotation from a paper read by me before the New Jersey Clay Workers' Association at the winter meeting at New Brunswick, N. J., Dec. 29, 1914, should serve to make clearer the fundamentals involved in the problem which confronted Mr. Dunkley:

. . . The combustion of coal in a furnace is a complex process, and the different combinations of equipment and methods of handling the equipment are almost infinite. And there are numberless kinds of coal. That statement is made advisedly. Considering alone the inherent characteristics, that is, the sulphur, volatile, ash, the fusing point of the ash, and the heating value of the coal, you can, within certain limits, find coals with all of these factors in any proportion you may desire. Here are five variables and each one has a considerable range of variation. In addition there is the variation in the physical condition of coal; that is, whether it comes in the form of dust—the slack—or screened to a certain size, or what is called the "run of mine." Then there is the question of coking or noncoking.

There are few, if any, industrial uses for coal which require definite adjustment of every one of these variables. Certain definite limits of part of the characteristics already mentioned are especially required in any particular case, without, however, limiting the remaining factors. The first point is, therefore, that you must know what factors are material in the selection of your coal before you can change to a new coal with any reasonable expectation of getting better results, or the same results at less cost.

The chief use of coal is to produce heat by its combustion. In any particular process to accomplish the best results a certain amount of heat must be released in a certain length of time. Let us assume for the present that this is the whole problem, disregarding all other questions, such as the avoidance of smoke, fumes injurious to the product, etc. That limits us to three variables—the heating value of the fuel per pound, the amount of fuel burning at one time, and the amount of fuel burned per hour. The first is determined by the selection of the fuel, the second by the area of the grates, and the third by the thickness of the fire and the amount of air supplied to it. It is obvious that if we change any one of the three, we will directly affect the result, which is a given amount of heat liberated in a given time. This may seem rather elemental, but the point I wish to bring out is that frequently the user tries to change one of these factors (usually the coal) without making corresponding readjustments in one or both the remaining conditions, with the result that he concludes there is only one kind of coal he can burn satisfactorily. Frequently, a minor change in equipment or methods of firing will make possible the use of another coal at considerably less expense.

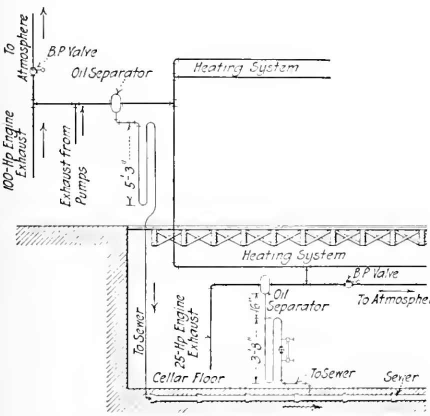
CARLTON W. HUBBARD.

Brooklyn, N. Y.

Trouble with Oil Separator

Can any POWER reader suggest a remedy for trouble with an oil separator? Since taking over my present plant I have had considerable annoyance from grease passing over with the steam into the heating system from the separator of a small engine located in the cellar, where the connections are arranged as in the accompanying sketch.

A new separator and various kinds and sizes of seals



ARRANGEMENT OF OIL SEPARATOR WHICH GIVES TROUBLE

have been tried without effecting a remedy. We carry 8 in. of vacuum and the grease is drawn through the separator. Several so called experts have seen the conditions and each has advised different sizes, loops, etc., but upon trial none of them has proved satisfactory.

H. G. GOODWIN.

Lachine, Que.

Industrial Education Again

My article on industrial education for operating engineers, which was published in POWER, July 28, 1914, was intended to draw out discussion. I was glad, therefore, to hear from William E. Dixon, in the Nov. 10 issue, even though he does not agree with me and thinks the sort of trade school I was connected with so long is a "pure and arrant fake."

This problem of industrial education is far from being solved; those who have worked the hardest and the longest realize that better than those who are on the outside looking in. Many mistakes have been made, and many more will be made. The fact remains, however, that the industries are today so organized that learning any trade under the old conditions is practically impossible. The few large shops which realize this fact are providing schools within their own walls. These have all the problems to meet which are met by the public trade school, if politics can be kept out of the latter, and that is possible.

There is no need to forget the cultural, civic or business side of a boy's education because he is in a trade school. I do not know what schools Mr. Dixon has seen, but his name is not on the visitors' book at the Worcester Trade School, so I am sure he has not been shown that school by anyone in authority able to explain what is really done there. While some things are far from perfect, they are not those to which he alludes. These schools should, and most of the state-aided schools do, give at least one-third of the pupils' time to regular high-school studies. Their hours are much longer, and consequently this time is almost equal to the total time which the regular high schools give.

Some interested in industrial education do believe a trade school should teach trades solely. We have never felt that we could conscientiously send out a graduate unequipped, so far as his mentality allows, for the battle of life.

It is not easy to find the right teachers. We had one for a short time who had a first-class license. He had handled some big plants and came well recommended He knew nothing except by rule of thumb, could not tell that to anyone else, and would not be helped by those who did know how to teach.

A man who knows what he is trying to teach, who has not forgotten that he was a boy, and who has a cheerful disposition has a fair chance of learning to teach by experience alone. Certain tricks of the trade of teaching he may learn from more experienced men. These relate almost entirely to discipine. The largest job is how to impart what one knows to students so that it makes an impression and is within their comprehension. When an engineer has done a certain thing for years he easily loses sight of why he does it. It is enough to tell a helper to do a thing, and he does it until it becomes a habit. That is not education. A man has not learned how to do a thing until he understands the reasons for doing it.

Mr. Dixon should prove his statement that "the schools cannot even hope to get an equipment that would serve for much more than a toy." There is no reason why a school's money should not go as far as that of any corporation. In fact, experience shows that it can be made to go farther than any other city money. Builders of the best machinery have made concessions that, taken alone, would fit out a school in far from toy fashion. The cost per pupil for adequate equipment is less than that for equally good machine-shop equipment.

Mr. Dixon hints that desirable boys will not go to school to learn to be engineers. That depends on what you will take. If you start a school with riffraff it will be hard to get decent boys into it. A school cannot afford to be snobbish, but it can make a manly attitude toward the work a condition of membership. There are plenty such boys, but they will not go where the other kind are tolerated in any considerable numbers.

"It is bad practice to try to teach a person an idea until that person has a desire to know it," says Mr. Dixon. If my father had humored me when I was a small boy, I would not have begun to get ideas yet. A boy should be taught while he is young and receptive. The instructor is of little use who cannot make steam engineering attractive to a boy. A boy must be brought to the point where he knows that it is up to him to learn before he will learn many things.

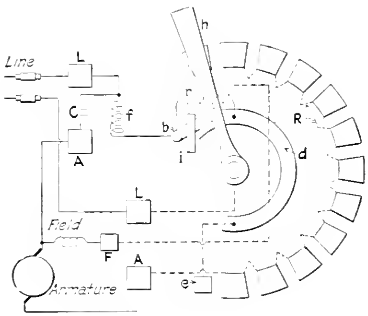
The crying ill of all our educational systems is that the pupils do not wake up to their needs until it is too late. They are so delicately handled now that they think they know much better what is good for them than their parents. The adequate substitute for the stiff stick in the hands of a raw-boned Yankee teacher as an idea awakener has never been found. If this notion that a boy should not be taught anything until he has discovered for himself that he needs to know it were ever followed except on paper, our schools would be picnics and education would be below zero.

E. H. Fish.

Worcester, Mass.

Contactor Closed and Opened

The diagram shows the connections of a starting-box used in conjunction with a contactor which ruptures the arc, thereby saving the rheostat contacts when the starter is thrown to the off position. It also acts as a no-voltage release to open the motor circuit should the line become dead, with no one in attendance. Upon simultaneously twisting handle *h* and moving it in a clockwise direction, an auxiliary contact arm mounted on *h*, and brought down by the twisting motion, touches the button *b*, to which is connected one end of the operating coil *f* of contactor *c*. This closes the local break through the contactor and the motor takes current. If the handle is kept twisted and in contact with *d*, as it is advanced, coil *f* will remain energized throughout the travel of the handle. At the end of its travel the handle engages a spring clip on post *e* and the twisting stress may be released, because coil *f* is then energized independently of the auxiliary contact.



Starting Device

It will be noted that at the start, when the auxiliary contact rests upon button *b*, the full line voltage is applied to the coil *f*, but after the contact reaches segment *d*, resistance *r* is cut into series with coil *f*. This is a feature of safety as well as of economy, because less current is required to hold the contactor closed than is required to close it; and if the voltage should leave the line, thereby causing the contactor to open, it would remain open until someone returned the starter to the "off" position and repeated the starting cycle, because with *r* in series with *f*, the current would be insufficient to close the contactor.

One of these outfits in a lumber camp, where it was exposed to the weather, was complained of because in going from the "off" to the "on" position the contactor would open immediately after closing. Insulation strip *i* is used simply to preserve a smooth surface for the auxiliary contact in its travel from button *b* to the segment *d*. Investigation showed the trouble to be due to this insulating strip having absorbed rain and so swelled as to raise the auxiliary contact finger out of contact with *b* before it had made contact with *d*. This, of course, demagnetized coil *f* and permitted the contactor to open. The trouble was remedied by sandpapering the surface of *i* below the surfaces of button *b* and of segment *d*. It is interesting to note that an open-circuit in resistance *r* may cause the same failure.

J. A. Horton.

Schenectady, N. Y.

Loss by the Use of Slack Coal

Here is an account of two boiler tests that may interest some engineer operating the Hawley down-draft furnace. Plants with these furnaces have their troubles when using slack coal. When we have mixed coal we can show good results, but with slack we cannot keep it on the top grate. The result is that we cannot carry the load with the same number of boilers on the line. With mixed coal I ran a test on Dec. 2, 1914, on a 150-hp. Coatsville fire-tube boiler with a Hawley down-draft furnace. The first test was very good, the evaporation from and at 212 deg. F. per pound of dry combustible being 11.66 lb., the horsepower-output 287, an over-rate of 91 per cent., and the efficiency of the boiler and furnace was 69 per cent. It cost 10.21 cents to evaporate 1000 lb. of water.

The following day I ran a test on the same boiler, with the same fireman, and tried to get as near to the first test as was possible, but using coal containing very few lumps. This second test showed a decided falling off. We evaporated 10.63 lb. of water per pound of combustible and developed 249 hp., an over-rate of 66 per cent. in place of 91 per cent. It cost 11.25 cents per thousand pounds of water in place of 10.21 cents and the efficiency was only 64 per cent. The loss in twenty-four hours on nine boilers amounted to $21.33 with slack coal.

Harry Biehl.

Philadelphia, Penn.

Commutator Short-Circuited

An inspector was called to find out why the armature of a motor was heating and "shooting like a gun." He ascertained that the commutator had just been slotted in a lathe. The side mica was very thin and the lathe tool used was too thick; the result being that the tool curled shavings from the bars and at the end of the stroke the stub of the shaving was jammed into the mica and across an adjacent bar. The burrs had been picked out where they could be seen, but some were too deeply embedded.

As soon as the motor was started, all the coils that were short-circuited by bridged bars were heated by the local short-circuit currents which, as the speed became greater, became sufficiently heavy to burn out the short-circuits that had not been picked out. The noise like the report of a gun was due to the extinction of the arc by the magnetic field. The motor was then run up to full speed and without any further demonstration. The arc-extinguishing properties of the magnetic field explain why armatures that burn out in service are not as badly damaged as might be expected.

J. A. Horton.

Schenectady, N. Y.

Inquiries of General Interest

Salt in Fireclay—What is the purpose of adding salt to fireclay used in setting the firebrick of boiler furnaces?

M. G. W.

The addition of about a pint of salt to a bucketful of ordinary fireclay causes partial vitrification of the fireclay when it becomes heated, and increases its adhesiveness to the firebrick.

Removing Stains from Gage-Glasses—How can stains be removed from boiler water gage-glasses?

S. M. E.

Most stains formed on boiler gage-glasses can be removed with a swab of clean waste moistened with a weak solution of muriatic acid. In the cleaning process care should be taken, however, not to employ wire or other material likely to scratch the glass and thereby weaken it.

Coefficients of Expansion—What are the relative rates of expansion of aluminum, brass and cast iron for the same increase in their temperature?

C. R. H.

The coefficients of expansion or proportionate increase of length for each degree increase of temperature of the metals named are: Aluminum, 0.00001234; brass, 0.00001; and cast iron, 0.00000556.

Bedding Underground Pipes in Sand or Gravel—What benefit is to be derived from bedding underground steam or water pipes in sand or gravel?

J. N. R.

The principal advantages obtained are more perfect grading and better subdrainage. In case of steam pipes, whether or not they are laid in conduits or coverings of any kind, subdrainage is important in reducing the convection of heat from the pipes to the surrounding earth, and in case of water pipes complete bedding in sand or gravel affords better protection against frost.

Drainage of Boiler Steam Main and Arrangement of Stop Valve—How should a main steam pipe slope and boiler stop valve be placed between a boiler and engine?

D. J.

The slope of the piping and arrangement of the stop valve should be such that all condensation between the valve and the boiler will drain back into the boiler, and the slope of the piping beyond the valve should be such that the water will drain from the boiler toward the engine. Stop valves should be so arranged that pressure from the boiler will tend to raise the valve from its seat, and they should be given such a position that there will be no accumulation of condensate above the valve when it is closed.

Care of Standing Boiler—When a boiler of a battery is not required for some time, is it injured by standing with water at the usual level carried for steaming?

W. B.

There will usually be more rapid corrosion of the interior above the regular water line, and especially near the water surface, when so standing than when steaming. When not required for some time, the boiler is better preserved by emptying it of water and drying thoroughly. If that is impracticable, interior corrosion can be reduced by completely filling the boiler with water, although for most situations this results in more rapid exterior corrosion than when the boiler stands empty, due to condensation of the moisture of the atmosphere.

Pressure in Discharge Pipe with Drop Leg—Neglecting pipe friction and inertia, what pressure would a pump have to work against if the discharge pipe rose to a height of 150 ft. and returned with an open end at the level of the pump?

G. K.

For starting flow in the descending leg, the pressure pumped against would increase to

$$150 \times 0.434 = 65.1 \text{ lb. per sq.in.}$$

As a column of water 34 ft. high would balance the pressure of the atmosphere, then if a solid column 34 ft. or more in height were maintained in the descending leg of the discharge pipe, a vacuum would be formed in the upper end of the ascending pipe, thus relieving it of pressure equal to that of the atmosphere. The net head pumped against would then be 150 — 34 or 116 ft., which would be equivalent to

$$116 \times 0.434 = 50.34 \text{ lb. per sq.in.}$$

Coal Required under Stated Conditions—With the temperature of feed water at 200 deg. F. and a combined boiler and furnace efficiency of 60 per cent., how many pounds of coal of a calorific value of 1",500 B.t.u. per lb. would be required to evaporate 13,600 lb. of water into dry saturated steam at 130 lb. gage pressure?

T. B.

The total heat required to convert a pound of feed water from 32 deg. F. into dry saturated steam at 130 lb. gage or 145 lb. absolute pressure would be 1192.8 B.t.u., and as each pound of feed water at 200 deg. F. would contain 200 — 32 or 168 B.t.u. above 32 deg. F., then to raise 13,600 lb. of water from 200 deg. F. to dry saturated steam at 130 lb. gage pressure would require

$$13,600 \times (1192.8 - 168) = 13,937,280 \text{ B.t.u.}$$

With a combined boiler and furnace efficiency of 60 per cent., from each pound of coal containing 13,500 B.t.u. there would be realized

$$13,500 \times 0.60 = 8100 \text{ B.t.u.}$$

and, consequently, the evaporation of 13,600 lb. of water under the conditions stated would require

$$13,937,280 \text{ B.t.u.} \div 8100 \text{ B.t.u.} = 1720 \text{ lb. of coal.}$$

Pipe Surface Required for Heating Water—How many lineal feet of 2-in. iron pipe, or of brass or copper pipe of the same size, would be required as heating surface in a closed tank to heat 800 gal. of water per hour from 50 to 180 deg. F. with exhaust steam at 1 lb. gage pressure?

A. M. D.

In raising the water from 50 to 180 deg. F., each pound would receive 180 — 50 or 130 B.t.u., and as 800 gal. of water would weigh $800 \times 8\frac{1}{3} = 6666$ lb., and, neglecting losses by radiation, the total heat to be transferred would be

$$6666 \times 130 = 866,580 \text{ B.t.u. per hr.}$$

As the temperature of the steam would be about 213 deg. F. and the average temperature of the water would be

$$\frac{50 + 180}{2} = 115 \text{ deg. F.}$$

then the mean temperature difference between the steam and the water would be

$$213 - 115 = 98 \text{ deg. F.}$$

For this mean temperature difference, iron pipe would condense about 18.5 lb. of steam per square foot per hour, and the latent heat of steam at 1 lb. gage pressure being 969.7 B.t.u. per lb., then for each square foot of pipe surface there would be a liberation of

$$18.5 \times 969.7 = 17,939.45 \text{ B.t.u. per sq.ft.}$$

so that

$$\frac{866,580}{17,939.45} = 48.3 \text{ sq.ft.}$$

of iron-pipe surface would be required. As 1.608 lin.ft. of 2-in. pipe would be required per square foot of external surface, the total heating surface would require

$$1.608 \times 48.3 = 77.7 \text{ lin.ft.}$$

of 2-in. iron pipe. Under the same conditions brass pipe would condense about twice as much and copper pipe about $2\frac{1}{3}$ times as much steam per square foot of surface, and therefore

$$\frac{77.7}{2} = \text{about } 38.8 \text{ lin. ft.}$$

of brass pipe, or

$$\frac{77.7}{2.33} = \text{about } 33.3 \text{ lin.ft.}$$

of copper pipe, of the same external diameter as standard 2-in. iron pipe, would be required.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Engineers' Study Course

Steam-Engine Cycles

The diagram representing the ideal performance of the steam plant is given in Fig. 1, repeated from Fig. 3 of the article on "Heat-Engine Cycles." A brief review of this Rankine cycle is as follows:

Line *AB* shows complete evaporation and the transfer of the steam to the engine or turbine, without loss of heat by radiation, loss of pressure by pipe friction or throttling, or loss of volume by initial condensation. Its right-hand end may also cover superheating, which, of course, takes place at boiler pressure.

Curve *BC* shows adiabatic expansion, possible only in a cylinder of some imaginary, thermally neutral substance. This expansion is carried clear down to the exhaust pressure at *C*.

Line *CD* represents complete expulsion of the steam from the engine and its contraction to the liquid state in the condenser (or atmosphere).

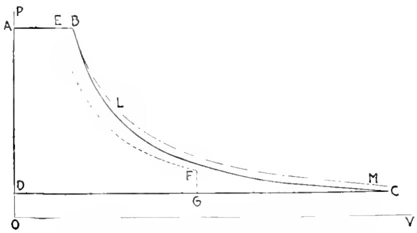


Fig. 1. Diagram Representing Ideal Performance of Steam Plant

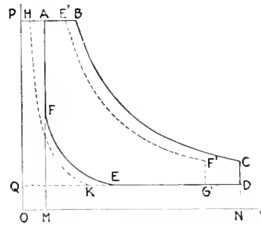


Fig. 2. Illustrating Clearance and Compression

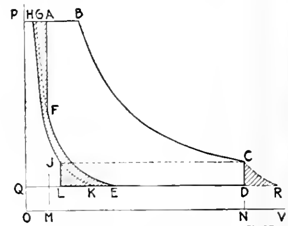


Fig. 3. Loss Due to Clearance

This diagram implies that the engine has no clearance at all. It is the form of ideal action in either piston engine or turbine, but the interpretation is somewhat different for the two types of machines. The engine will now be considered.

Area *ABCDA*, Fig. 1, shows the maximum output of work per pound of steam, within the particular limits of pressure and temperature, and the best possible efficiency. In the actual plant there are four ways or directions in which this ideal performance fails of realization. These sources of loss are:

(1) Pipe and valve losses, of heat and pressure, incurred in the transfer of steam to and from the cylinder.

(2) Thermal action of the cylinder walls.

(3) Incomplete expansion.

(4) Clearance and compression.

Of these, Nos. 2 and 3 will first be taken up, then No. 4, and finally No. 1; and in the consideration of them the evolution of the actual indicator diagram from the ideal outline *ABCDA* will be shown.

The effect of initial condensation, by the cooler metal surfaces with which the steam entering the cylinder comes into contact, is evidenced in the shrinkage of steam volume from *AB* to *AE*. And then, because the heat thus taken from the steam at high pressure begins to come back as pressure and steam temperature are lowered, curve *EF* falls less rapidly than would an adiabatic from *E*. In shape, curve *EF* is here drawn as an equilateral hyperbola, following the law

Pressure × *volume* = *a constant*, or $pv = c$.

Sometimes the hyperbola is called the theoretical curve of steam expansion. The title is undeserved, for thermal conditions within the cylinder are so complex that the formulation of any theory of expansion is impossible. The very prevalent use of this curve in laying out preliminary or illustrative diagrams is based on two wholly practical facts or considerations. The first is that the hyperbola is a fairly good working average of the expansion curves of actual indicator diagrams; the second, that it is an easy curve to plot.

The best collection and discussion of data as to the form of real steam curves that have been made will be found in the paper on "Cylinder Performance," presented to the American Society of Mechanical Engineers by J. Paul Clayton, in May, 1912, and reviewed in Power for June 18, 1912. The subject is too extensive for more than a reference here. It is enough to say that when there are conditions favoring excessive cylinder-wall action, such as small size and low speed, with early cutoff, the expansion curve will run much above the hyperbola. On the other hand, with high superheat and small thermal action, it will fall much more rapidly. But in the general run of ordinary conditions, departures from the form $pv = c$ are comparatively small.

Returning to Fig. 1, it will be noticed that the assumed curve *EF* rises steadily toward the adiabatic *BC* as the steam expands. In further illustration of the same point, curve *LM* is a hyperbola drawn from *B*. The vertical distance between *LM* and *BC* at first grows larger, then diminishes; but when it is remembered that this difference is a relative quantity, to be compared with the whole pressure from base line *OV* up to the curves, it is seen to increase progressively.

Now in ideal operation, or in the process reasoned out for getting the maximum work from a pound of steam, expansion is carried clear down to exhaust pressure. There is very good reason why this ought not to be done in the real engine, and why it is more economical to stop at some such point as F. To get the small amount of work represented by the triangular area to the right of line FG would require a cylinder more than twice as large as is needed to contain volume DG. First of all, this would make the engine cost more, but worse than that, it would involve continual losses in operation. If the cylinder is too big and cutoff too early, the waste due to thermal action by the cylinder walls becomes relatively greater. And in driving the piston by a small mean effective pressure such as will prevail beyond FG, the loss of work through machine friction will exceed the effective work done by the steam upon the piston, and the result will be a net loss rather than a gain.

The matter of clearance and compression is taken up in Fig. 2. As the first step, the combined expansion and release lines $E'F'G'$ are transferred directly from Fig. 1. These lines represent the performance, in an engine without clearance, of one pound of steam which enters the cylinder, does work, and goes to the exhaust. But now there is to be associated with this working steam a certain proportionate amount of clearance steam. In Fig. 2, the volume PE' of the working steam in its condition at cutoff is moved out to HB, leaving back of it a space PH

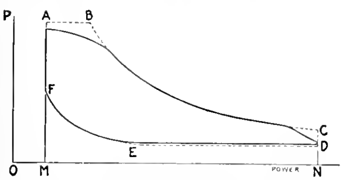


Fig. 4. The Diagram Obtained in Practice

filled with clearance steam. Of course, this division is imaginary, for there is no separation into distinct volumes. The point is that, of the steam present at cutoff, a portion HB is going to be discharged, while the remainder PH will be caught and compressed.

As the whole body of steam expands along curve BC, the clearance quantity has its increasing volume measured out to the similar curve HK. Since these curves are taken to be of the same form as $E'F'$, horizontal distances between curves HK and BC are the same as between line OP and curve $E'F'$. In effect, then, the original no-clearance diagram $PE'F'G'Q$ is shifted over to the right of curve HK. This distorts its shape, but does not change its area above a horizontal line through F' or C; below that pressure, however, there is a loss, the cause of which can be stated in two ways. The first is, that $F'G'$ would be changed to a curve CR, as shown in Fig. 3, at a constant distance from curve HK; and the vertical release line CD cuts off the extended area CRD. The other form of statement is, that since effective volumes of the working steam are measured over from curve HK, and these grow shorter below the terminal pressure at C, the lower end of HK cuts under the effective diagram and diminishes its area.

The loss due to clearance is more fully illustrated in Fig. 3. At the beginning of expansion the steam in the cylinder is partly condensed, because of wall action. At the beginning of compression the steam left in the cylinder is likely to be nearly or quite dry, perhaps even a little superheated. Consequently, the quality of the clearance steam is higher at E than at K, and its volume is greater; then the compression curve runs to the right of HK, or the clearance steam requires more work for its compression than it gives back in expansion.

The lost area $CRDC$ is, in effect, an addition which compression makes to the work not utilized because of incomplete expansion. This triangular figure may be carried over to the position $JKLJ$; and then we say that while the clearance steam really follows curve HK all the way down to exhaust pressure, its effective delivery of work ends at the pressure of release. Any work of expansion to the right of JL simply helps the outrush of steam during release. A condensed statement regarding clearance losses may be made as follows:

If the whole weight of steam represented by volume PB came from the boiler into an engine without clearance, it would do the work represented by area $PBCDQP$, Fig. 3.

Actually, because of clearance and compression, the useful work really performed is only that represented by area $ABCDEFA$.

But the area $PAFEQP$ is not all loss, for a part of it is covered by the work $PHJLQP$ of steam which did not come from the boiler, but was saved over from the preceding cycle. The net loss is then the shaded area $AFELJHA$.

This lost area is made up of three parts. In order to separate them, the compression curve is extended as FG, here made similar to HK. This continues up to admission pressure, the prevailing difference in quality between compression and expansion, and shows a complete working cycle $EGHKE$ for the clearance steam. Then the three partial losses are:

Area $AFGA$ due to throttling of the live steam as it enters and fills the clearance space.

Area $EGHKE$ due to cylinder-wall action, working out through the cycle of operations of the clearance steam.

Area $JKLJ$, in effect, as has been explained, an addition to the incompleteness of expansion.

In regard to the proportions of this diagram, it is to be noticed that the difference between curves EG and HK is exaggerated, being too great relative to the quality at cutoff shown by the ratio of AE to AB in Fig. 1.

The ideas developed in Fig. 3 open the way to a more or less definite rational determination of the best degree of compression corresponding to a certain set of conditions on the expansion side of the indicator diagram. The indefiniteness is due in part to uncertainty as to the exact form of the expansion and compression curves in the actual engine, and for the rest to modification of the sharp-cornered diagram by the pipe and valve effects shown in Fig. 1. But this general idea of the several sources of loss makes it easier to understand the results of experiments made to determine the effect of compression upon economy.

In Fig. 4, the outline $ABCDEFA$ is the same as in Figs. 2 and 3, but its proportions are changed to something nearer those of common indicator diagrams. It only remains, then, to sketch in curves of admission and release and a line of increased back pressure, and thus come to the end of the evolution of the actual indicator diagram. Knowledge of the magnitude of these pipe and valve effects comes wholly from experience, or from familiarity with the performance of the various classes of engine.

Performance of Refrigeration Plant at Lubeck, Germany*

SYNOPSIS—Description and data of test results of the municipal refrigeration plant at Lubeck, Germany. The poppet-valve compressor engines use highly superheated steam and some exhaust steam is used for ice making. Unusually good results are obtained.

In contracts for ice-making and refrigerating machinery it is customary for the manufacturer to guarantee the capacity, to enumerate the temperatures to be maintained in cold-storage rooms, and, if the purchaser is exacting, to insert the guarantees for coal, steam, power and cooling-water consumption. A test is usually made to see if the machinery supplied fulfills the various requirements. Such tests are instructive, but for commercial reasons, probably, they seldom get into print.

In the following only the acceptance tests of the equipment of the refrigeration plant for the city of Lubeck, Germany, are given.

The mechanical equipment of the "Kuhlhaus Lubeck" consists essentially of one 17$\frac{3}{4}$ and 29$\frac{1}{2}$ by 29$\frac{1}{2}$-in. tandem-compound Swiderski steam engine of 320 hp., using superheated steam, connected to a Balcke surface condenser. In the connection between the low-pressure cylinder and the surface condenser is inserted an oil separator. From the condenser the condensate is taken to a reboiler for the purpose of expelling air and foreign gases, a portion of this water being required for making distilled water ice, and the remainder is returned to the boiler. The distilled water is forecooled in a countercurrent cooler.

This main engine is coupled to a pair of 13x23$\frac{5}{8}$-in. double-acting horizontal Borsig ammonia compressors of the opposed type. A duplicate engine, intended for reserve, is connected to a single ammonia compressor 13x23$\frac{5}{8}$ in.

To take advantage of the increased capacity obtained when operating with a higher evaporating or suction pressure, one of the four ends of the double compressor unit is used only for ice making, keeping the brine in the freezing tank at about 19 deg. F. The guaranteed capacity of this compressor cylinder half is 36.4 tons or

$$110{,}000 \text{ calories} \times 3.9683 = 436{,}513 \text{ B.t.u. per hour.}$$

The ice-tank room and brine tank are designed on the Linde system, the brine-cooling coils being placed underneath instead of between the cans. The rated daily capacity is 22 tons of 2000 lb. each.

With the 300- or 400-lb. American blocks the freezing time is 42 to 60 hours, while the small European 55-lb. blocks (average size 7x7x35 in.) with 19-deg. brine freeze in 18.4 hours; there are 612 of these small cans in the freezing tanks.

When cooling brine to 14 deg. F. for the cold-storage warehouse the guaranteed capacity of any one of the compressor cylinders is 61.15 tons of refrigeration. (One ton of refrigeration = 2000 × 144 B.t.u. = 288,000 B.t.u. per 24 hours.) The brine is cooled by direct-expansion coils. The brine tank has circulation partitions and agitators. Another tank, supplied with cold water, is used for cooling the liquid ammonia. The ammonia condensers of the atmospheric type are on the roof.

From the flywheel of each engine a belt leads to a lineshaft under the engine-room floor, and from this lineshaft are driven two 70-kw. Siemens-Schuckert generators, one being a spare. The boiler house has two Borsig water-tube boilers, one a spare, built for 170-lb. pressure and superheating to 625 deg. F. Each boiler has 969 sq.ft. of heating surface.

The cooling water supply, guaranteed capacity 268 gal. per minute, is obtained from two wells. The water in one is lifted 131 ft. to the surface, in the other 98 ft., by a Borsig air compressor, also in duplicate. The water is discharged into a receiving basin near the boiler house, and forced to the ammonia condensers by a belt-driven volute pump. A duplicate pump, driven electrically, is provided for this service. As a further safeguard for insuring uninterrupted operation, provisions are made for using city water if necessary.

For producing the necessary hot water for scalding purposes in the abattoir a steam-heated hot-water apparatus is erected in the boiler house; capacity 26.5 gal. of water per minute heated from 86 deg. to 176 deg. F. Preheated water is taken from the surface condenser, the latter in turn receiving its cooling water from the ammonia condensers. In this manner the water is utilized to the fullest extent. Steam meters measure the quantity of live steam fed to the hot-water apparatus. The plant is well equipped with all kinds of indicating and recording instruments.

The following is abstracted from the report of acceptance tests made after all the machinery had been installed and operated during the summer of 1913.

BOILER TEST

Of the two boilers, which are alike, only the one which happened to be clean at the time was tested, it being assumed that the other boiler would have shown equal efficiency.

Date of test	Oct. 18,1913
Type of boiler (Borsig Steilrohr Kessel)	Water-tube
Number of boiler and year built	20,994—1913
Evaporating surface, sq.ft	969
Superheating surface, sq.ft	269
Grate surface (flat) total, sq.ft	36.2
Economizer, sq.ft	377
Guaranteed performance:	
Evaporation normally, 5070 lb. water per hour; 3968 lb. steam to be superheated.	
Overall efficiency, per cent.	76
Temperature of superheated steam, deg. F.	625
Gage pressure, lb	170
Conditions:	
Heating value per pound of coal as fired, minimum B.t.u.	11,500
Permissible residue, per cent	6
Draft after passing economizer, at least 0.6 to 0.8 in. of water column.	
Feed-water temperature, not less than 95 deg. F.; from economizer, 158 deg. F.	
Coal analysis:	
Average calorific value of coal sampled, 12,145 B.t.u. per pound as fired.	
Results of test:	
Date	Oct. 18, 1913
Load	Normal
Duration of test	4 hr. 2 min.
Temperature of fireroom	57.2 deg. F.
Draft at rear of boiler, in. water column	0.3
Draft after passing economizer, in. water column	0.68
Flue-gas temperature after economizer, deg. F.	405
Flue-gas temperature at rear of boiler, deg. F.	653
Per cent. of CO_2	13.38
Per cent. of O	5.72
Steam pressure, gage, lb	167
Steam pressure, absolute, lb	181.7
Temperature of superheated steam, deg. F.	628
Temperature of saturated steam, deg. F.	374
Amount of superheat, deg. F	253
Total heat of saturated steam (above 32 deg. F.) B.t.u. per lb	1,197
Heat of superheat, 254 × 0.646 (spec. heat) B.t.u. per lb	164
Total heat of superheated steam, B.t.u	1,361
Feed-water temperature to economizer, deg. F.	97.1
Feed-water temperature from economizer, deg. F.	181.3
Heat supplied in boiler, per lb. of superheated steam, B.t.u., 1361 — (97.1 — 32) =	1,295.9
Water evaporated during test, lb	21,076
Water evaporated per hour, lb	5,225
Water evaporated per hour per sq.ft. heating surface, lb.	5.39
Coal consumed during test, lb	2,595
Coal consumed per hour, lb	643
Coal consumed per hour, per sq.ft. grate surface, lb.	17.8
Water evaporated during test, per pound of coal fired, lb. 5225 ÷ 643	8.14
Heat contained in 1 lb. of saturated steam = 1197 — (97.1 — 32), B.t.u	1,132.9
Ash and refuse, percentage	9
Heat imparted to saturated steam per lb. of coal as fired, B.t.u., 8.14 × 1131.9 =	9,214
Efficiency of boiler and economizer, referred to saturated steam, per cent., $100 \times \frac{9214 \text{ B.t.u. in steam}}{12{,}145 \text{ B.t.u. per lb. coal}}$ =	76

At the time of this test it was impossible to ascertain the steam consumption of the main engine, which would have shown the capacity of the superheater. Therefore, the over-all efficiency of steam generation could not then be had. However, a month later the steam consumption of the engine was found to be 2888 lb. of superheated steam per hour. The work done by the superheater may, therefore, be taken at

$$2888 \times 164 \text{ B.t.u.} = 473.632 \text{ B.t.u.}$$

This divided by 643 results in 736.6 additional heat units obtained per pound of coal fired, making the total

$$9214 + 736.6 = 9950.6 \text{ B.t.u.}$$

*Excerpts from an article by Richard Stetefeld, "Eis Und Kalte Industrie."

The heat utilized by the boiler, economizer and superheater, based on coal as fired, is

$$100 \times \frac{9950.6}{12,145} = 82 \text{ per cent.}$$

Based on combustible it is

$$100 \times \frac{9950.6}{12,145 \times 0.91} = 90 \text{ per cent.}$$

The number of pounds of superheated steam obtained per pound of coal as fired is

$$\frac{9950.6}{1295.9} = 7.68 \text{ per cent.}$$

A repetition of this test was deemed unnecessary because substantially the same results had been secured at a preliminary test.

TEST OF ENGINE COUPLED TO AMMONIA COMPRESSORS

An official trial of the tandem-compound main engine with 17¾ and 29½ by 29½-in. cylinders, of the poppet-valve type, coupled to two 13x23⅝-in. opposed ammonia compressors, was conducted. The reserve engine, a duplicate, was not tested for steam consumption, because the indicator diagrams taken from it under like conditions agreed with the diagrams obtained from the main engine, proving that the power and economy of the two engines in the plant are the same.

Dimensions and Conditions Imposed:	
Diameter of high-pressure cylinder, in.	17.718
Diameter of high-pressure piston rod, in.	3.736
Diameter of high-pressure tail rod, in.	2.749
Diameter of low-pressure cylinder, cold, in.	29.525
Diameter of piston rod, crank end, in.	4.128
Diameter of piston rod, head end, in.	3.736
Stroke, in.	29.527
Revolutions per minute	95
Gage pressure of steam at throttle, lb.	164
Temperature of steam at throttle, deg. F.	572
Cooling surface of surface condenser, sq.ft.	592
Amount of cooling water supplied per hour, cu.ft.	2120
Temperature of cooling water, deg. F.	68
Guarantees:	
Indicated English horsepower of engine, normally	320
Indicated English horsepower of engine, maximum	394
Steam consumption per English i.hp.-hr., lb., at normal load	10.5
Steam consumption per English i.hp.-hr., lb., at maximum load	11.2
Mechanical efficiency of engine, per cent., at normal load	89
at maximum load	90

As for guaranteed efficiency of the exhaust-steam oil separator, the amount of oil remaining per thousand pounds of condensate was not to exceed 0.003 lb.

Results:	
Horsepower indicated	275.9
Revolutions per minute	95
Gage pressure of steam at throttle, lb.	160
Temperature of steam at throttle, deg. F.	576.3
Receiver pressure, inches mercury	5.7
Vacuum, inches mercury	27.6
Duration of test, hr.	4.8

The steam consumption of the engine was found to be 2888 lb. per hour. In calculating the indicated horsepower from the diagrams due allowance was made for the expansion of the cylinders under working temperature. The result was 275.9 i.hp. Accordingly, the steam consumption per indicated horsepower-hour during the test was

$$\frac{2888 \text{ lb.}}{275.9} = 10.47 \text{ lb.}$$

The coal consumption per i.hp. per hour was

$$\frac{10.47}{7.68} = 1.363 \text{ lb.}$$

This consumption, it will be noted, was obtained while the pressure of admission and the load were slightly below the figures stipulated in the contract. The normal indicated horsepower of 320 was not developed because the attached ammonia compressors and auxiliary machines required less than 320 i.hp. Diagrams show that the engine is easily capable of developing 320 i.hp., and will not at this load exceed the consumption guaranteed. By lengthening the cutoff the maximum power of 394 i.hp. may be obtained.

TESTS OF COLD STORAGE AND ICE PLANT

Of the two double-acting opposed Borsig ammonia compressors coupled to the engine one and one-half compressor cylinders operate on the cold-storage plant, cooling brine to 14 deg. F., while the fourth compressor cylinder half operates on the ice-making tank, cooling brine to about 19 deg. F. The refrigerating capacity of the one and one-half compressor cylinders was ascertained by measuring with Poncelet nozzles the column of circulating brine cooled per hour through an observed range of temperature. The fourth compressor-cylinder half as well as the single compressor of the reserve engine were indicated to ascertain their working conditions and refrigerating capacity.

Dimensions and Conditions Imposed:	
Diameter of ammonia compressors, in.	12.992
Piston-rod diameter (no tail rod)	3.643
Stroke, in.	23.622
Revolutions per minute	95
Exterior pipe-cooling surface, sq.ft. in brine-cooling tank	3,229
in ice-making tank	1,292
in ammonia liquid cooler	291
in atmospheric ammonia condenser	4,338
Temperature of circulating brine in tank, deg. F.	14
Temperature of brine in ice tank, normal, deg.	19.4
Temperature, initial, of condenser water, deg.	50.0
Temperature of liquefaction of ammonia, deg.	71.6
Temperature of under-cooled ammonia, deg.	52.7

Guaranteed tons refrigerating capacity of one compressor when cooling brine to 14 deg. F. equals

$$\frac{185{,}000 \text{ calories per hour}}{3023.95} = 61.2 \text{ tons.}$$

Same for one and one-half compressor cylinders, tons	91.8
Guaranteed daily ice-making capacity of one compressor-cylinder half from distilled water cooled to 53.6 deg. F., lb.	44,000
Indicated horsepower of one compressor when cooling brine to 14 deg. F.	57.2
Indicated horsepower of one compressor-cylinder half, cooling brine to 19.4 deg. F.	33
Consumption of 50-deg. F. condenser water, gal. per min.	265

The power consumption expressed in horsepower was as follows:

One and one-half compressor cylinders, cooling brine	85.8
One-half compressor cylinder making ice	33
Steam-condenser pump	4.4
Water-supply pump	20.5
Brine-circulating pump	9.7
Brine-circulating pump	8.8
Generator, $\frac{70 \text{ kw.} \times 1.34}{0.925}$ =	101.5
Losses in transmission	29
Total	292.7

Dividing by 0.89, the mechanical efficiency, the indicated engine horsepower necessary according to the guarantee is 328.4.

Capacity of brine-circulating pump for brine-wetted air-cooler, per min., gal.	396.5
for frosted air-cooler, per min. gal.	396.5
Current consumption of ice crane, kw.	2.5
Current consumption of fans, kw.	13.5

Results of tests made Oct. 18 to 21, and Nov. 21, 1913. Refrigerating capacity of one and one-half compressor cylinders:

Quantity of brine circulated per min., gal.	543
Heat capacity per gal. of salt solution per deg. F. temperature rise, B.t.u. = $\frac{62.35 \text{ lb.} \times 0.946}{7.4805}$ =	7.88
Temperature of incoming brine, deg. F.	19.9
Temperature of outgoing brine, deg. F.	13.8
Temperature reduction of brine, deg. F.	6.1
Heat abstracted from brine per min., B.t.u. 543 × 7.88 × 6.1 =	26,100
Corresponding tons of refrigeration performed by one and one-half compressor cylinders, $\frac{26{,}100}{200}$ =	130.5

Excess capacity of the one and one-half compressor cylinders over the capacity guaranteed = 130.5 — 91.8 = 38.7 tons, or 42* per cent.

In connection with this brine-cooling test the following interesting temperatures were noted:

Temperature of ammonia at suction pressure, deg. F.	5
Corresponding gage pressure, lb. per sq.in.	19.1
Temperature of ammonia in suction pipe of compressor No. 1, which operates with the same suction pressure in both ends, deg. F.	4.1
Temperature of ammonia in suction pipe of compressor No. 2, only one-half of which operates on the brine tank, deg. F.	6.3
Corresponding gage pressure, lb per sq.in.	20.2
Temperature of saturated ammonia at discharge pressure, deg. F.	74.6
Corresponding gage pressure, lb. per sq.in.	125.5
Temperature of ammonia in discharge pipe No. 1 compressor, deg. F.	187.7
Extent of superheating, deg. F., 187.7 — 74.6	113.1
Temperature of ammonia in discharge pipe of No. 2 compressor, deg. F.	182.2
Temperature of liquid ammonia leaving aftercooler, deg. F.	54.4
Temperature of ammonia entering brine-cooling coils, deg. F.	14.6
Temperature of ammonia vapor at inlet to atmospheric condensers, deg. F.	148.8
Temperature of liquid ammonia leaving condensers, deg. F.	65.4
Temperature of cooling water,	
to liquid ammonia cooler, deg. F.	48.9
from liquid ammonia cooler, deg. F.	55.8
leaving ammonia condenser, deg. F.	65.4

Under the above conditions the double compressor (with cylinders Nos. 1 and 2) was running at 94.5 r.p.m., and the

*The amount of this excess capacity suggests the possibility of error in the quantity or specific heat of the brine.

diagrams taken showed the following indicated horsepower:

Compressor No. 1, working full..	78.85
Compressor No. 2, one end only..	39.16
Total indicated horsepower..	118.01

Thus the indicated compressor horsepower per ton of refrigeration in cooling brine to 14 deg. F. was

$$\frac{118.01}{130.5} = 0.904 \text{ per ton,}$$

while the guaranteed power consumption had been equivalent to

$$\frac{57.2}{61.18} = 0.935 \text{ i.hp. per ton refrigeration.}$$

The piston displacement (area × stroke × r.p.m.) of compressor No. 1 is as follows.

$$12.992^2 \times 0.7854 = 132.6 \text{ sq.in.}$$

less one-half the area of the rod or 4.93 equals 132.6 — 4.93 = 127.67 sq.in., which, times the stroke of 23.6 in., is 3013 cu.in.; and this multiplied by 94.5 × 2 strokes = 569,500 cu.in. as the displacement of the cylinder.

The brine-cooling half of compressor No. 2 has a displacement of 273.900 cu.in., and the total for the one and one-half cylinders is 843,400 cu.in. per minute.

Thus the piston displacement per minute per ton of refrigeration when cooling brine to 14 deg. F. was 6419 cu.in.

The piston displacement of the head end of compressor No. 2, making ice, is 3132 cu.in., which times 94.5 strokes gives 296,000 cu.in. per minute, or 40 tons of refrigeration when cooling brine to 14 deg. F.

Since it requires, with the water available, at most 1.6 tons of refrigeration to produce one ton of ice, the ice-making capacity of this compressor-cylinder half is 28.7 tons in twenty-four hours, or 26.3 tons for twenty-two hours' operation daily. The guaranteed capacity of 22 tons is, therefore, exceeded.

The indicated horsepower of the fourth compressor-half when cooling brine to 14 deg. F. was 39.65, equivalent to

$$\frac{39.65}{28.7} = 1.38 \text{ i.hp. per ton of ice,}$$

which corresponds to 1.55 i.hp. in the steam cylinder of the engine.

During the brine-cooling test the cooling water was supplied by the electrically operated volute pump located in the boiler house. The quantity delivered at 1985 r.p.m. was found to be 252 gal. per min. Consequently more than the normal quantity of work was done with less water than the 268 gal. allowed under the guarantee.

The power indicated at the main engine was 283.32 i.hp., and the total power consumption of the establishment was but 9 per cent. more than was guaranteed.

The delivery capacity of the deep-well pump also was checked by noting whether the water level in the receiving basin remained constant while the cooling-water pump was discharging to the condensers at the rate of 268 gal. per min. It was found that even then some water returned to the wells, consequently the well pump was fully up to the capacity guaranteed.

The various features of special interest in the plant are the consistent use of reserve machinery, the obtaining of all power from one economical engine using superheated steam, making ice as a byproduct from exhaust steam, the efficient boiler plant, also the comparatively high rotative speed of the compressors (95 r.p.m., against 80 to 60 in this country). The low coal consumption and low power consumption lead to an unusual economy in the ice-making department. The coal consumption per indicated horsepower-hour was 1.365 lb., or 32.76 lb. per twenty-four hours. This, multiplied by 1.55 i.hp. per ton ice, equals 50.8 lb. Increasing this by 33⅓ per cent. to cover all possible auxiliaries, the total is 67.7 lb. Thus the number of tons of ice made per ton of coal fired is

$$\frac{2000}{67.7} = 29.5.$$

In American plants 10 tons of ice per ton of coal is considered quite satisfactory. It must be remembered in this connection that the initial temperature of the cooling water was 50 deg. F., the suction pressure nearly 20 lb. gage, and the condenser pressure only 126 lb. gage. The remarkable economy of this plant is directly traceable to these favorable operating conditions and to the use of a compound condensing engine using highly superheated steam for driving the compressors and for all the auxiliaries of the plant. The required distilled water for filling the ice cans was obtained only because the refrigerating effect needed to make the ice was only 26 per cent. of the total refrigerating effect produced by the two compressor cylinders. The total amount of steam passing through the engine was 34 tons per day, which, after deducting the water of condensation and other losses, would not have yielded quite enough distilled water for making the maximum of 29.5 tons of ice per day.

An Eight-Cylinder Gasoline Engine*

By Henri G. Chatain†

The object of this paper is to describe and discuss the features of design of an eight-cylinder, four-stroke cycle gasoline engine, which has been developed during a number of years for railway traction.

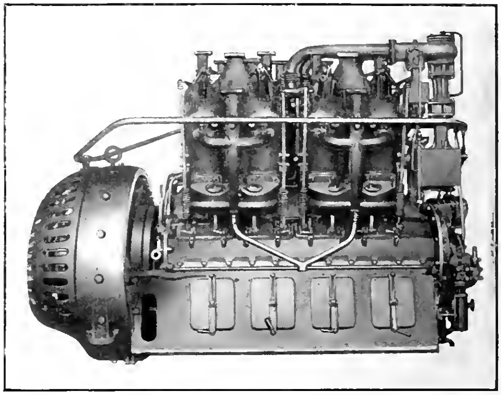


Fig. 1. Side View of Eight-Cylinder Engine

The problem was to design a complete motor car for branch railway service, of sufficient size for seating fifty passengers and a small baggage compartment, etc., and capable of attaining a maximum speed of 50 miles per hour on level track. The first design included an eight-cylinder V-type, 90-deg. engine, with cylinders 7½x8 in., and running normally at 550 r.p.m. This operated commercially in a little car on a Western road until quite recently, when it was destroyed by fire. The second attempt was a larger and heavier engine of essentially the same type. This was run experimentally in service 50,000 miles in one year on various roads, and served its purpose admirably in showing up some glaring defects, among which were the following:

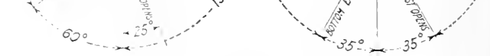


Fig. 2. Timing Diagrams

1. The exhaust valves needed regrinding once a week, as they were unduly distorted and burnt.
2. The camshaft and valves were extremely inaccessible.
3. It was uncommercial to make the cylinders sufficiently strong.
4. It was difficult to mount the engine in the car so as to take care of the horizontal component of the reciprocating forces; hence, there was vibration.
5. The total width of the engine was excessive.

With these facts at hand and an ever-increasing demand for more power, the third and present engine, which fulfilled expectations and met conditions, was designed. Fig. 1 gives

*From a paper presented before the Society of Automobile Engineers.
†Engineer, Gas Engine Department, General Electric Co.

an idea of its construction. To overcome the first difficulty mentioned, auxiliary exhaust valves with port entrance to the cylinders were embodied in the design. The cams actuating these valves are so laid out that the valve is entirely free of its seat when the piston passes the port opening. The timing is shown in the diagrams of Fig. 2. This arrangement

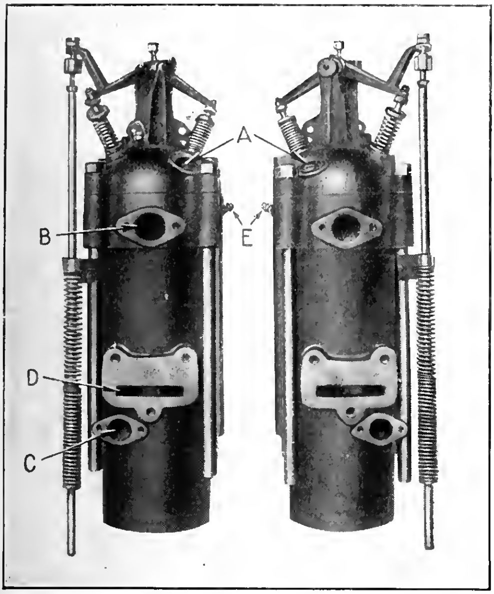


FIG. 3. SHOWING CYLINDER CONSTRUCTION

has worked well, and the auxiliary valves need practically no attention except about once a year. The exhaust valves in the head need to be ground about every 50,000 miles.

The second change was the relocation of the camshaft due to its inaccessibility, and also because the stroke of the engine was to be lengthened. Two externally located camshafts

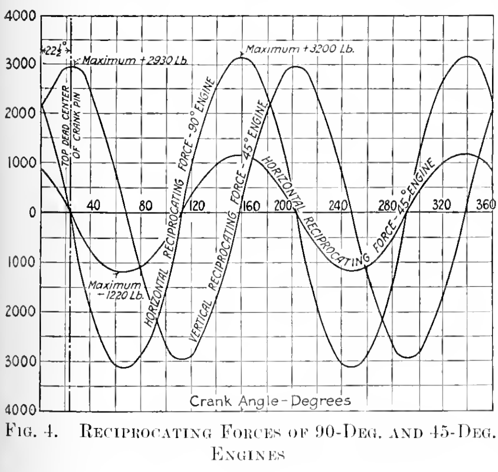


FIG. 4. RECIPROCATING FORCES OF 90-DEG. AND 45-DEG. ENGINES

were decided upon, with the cams, shafts, etc., running in a bath of oil. One actuates the auxiliary exhaust valve, and the other imparts the proper motion to the long push rod extending to the top of the cylinder and connected to the intake and exhaust valves.

In an engine of this size the L-head form of cylinder had little to recommend it. The castings had to be made very heavy, otherwise they would crack; and heavy castings interfere somewhat with the cooling. Extremely strong construction at this point was essential. Fig. 3 shows the form of cylinder construction adopted, namely, a barrel, a head and valves contained therein, held down to the base by long studs. Note that the water-circulating systems of the head and the barrel are distinct. The arrangement of two valves actuated from one cam is quite satisfactory at 500 to 600 r.p.m. With higher speeds the design would be unsatisfactory, as the mass of the moving parts would necessitate unduly high spring pressures. In Fig. 3, A indicates the make-and-break spark plugs, E the air-starter valves, C and B the water inlets, and D the exhaust ports.

A 45-deg. angle between the rows of cylinders was decided upon, to decrease the horizontal component of the reciprocating forces as well as the overall width. Thus each cylinder is set 22½ deg. from the vertical.

The crankshaft has four crankpins, of which the two outer are 180 deg. from the two inner pins and two pistons are attached to each pin. The connecting-rods are mounted side by side on each crank. It was thought advisable to adopt this construction for mechanical simplicity. The piston-pins are held fast in the rods and find their bearings in the piston proper. No bushings are used.

The reciprocating forces for one cylinder along its axis are

$$0.0000284 \times W \times r \times N^2 \left(\cos\theta + \frac{\cos 2\theta}{n}\right) \text{ lb.}$$

W = Weight of reciprocating parts = 59 lb.;
r = Crank throw in inches = 5;
N = R.p.m. = 550;
n = Length of connecting-rod divided by throw of crank = 4.5;
θ = Crank angle in the direction of rotation from top dead center of piston.

Fig. 4 shows the reciprocating forces for this engine represented graphically and compared with the 90-deg. cylinders.

The specifications of this engine are as follows:

Cycle		4
Number of cylinders		8
Revolutions per minute		550
Bore		8 in.
Stroke		10 in.
Displacement		503 cu.in.
Valve area:	Inlet	7.07 sq.in.
	Exhaust	4.91 sq.in.
Valve lift		½ in.
Mean velocity of air in intake pipe		7100 ft. per min.
Exposed radiating surface per cylinder:	Max	384 sq.in.
	Min	133 sq.in.
Projected bearing surface:	End	24 sq.in.
	Center	15 sq.in.
Section of connecting-rod:	Max	2.58 sq.in.
	Min	1.57 sq.in.
Number of bearings		5
Length of cylinder		23⅛ in.
Length of piston		11⅝ in.
Piston-pin center below piston top		5⅝ in.
Number of rings		6
Ring size		½ in.
Ring spacing		¼ in.
Length of connecting-rod, c. to c.		22½ in.
Diameter of piston-pin		2 in.
Diameter of shaft		4 in.
Length of end bearings		6 in.
Length of center bearings		3¾ in.
Number of camshaft bearings		4
Length of camshaft bearings		2½ in.
Diameter of camshaft		1½ in.
Cylinder-wall thickness		½ in.
Water space around cylinder		¾ in.
Height overall		6 ft. 3⅝ in.
Length less generator		7 ft
Length including generator		9 ft. 3 in.
Width overall		4 ft. 7¼ in.

Alaskan Coal

Last year a sample of coal from the Bering River field in Alaska was tested by the Navy Department and found to be unsatisfactory for the use of the navy. A test has since been made with coal from the Matanuska field, of which Admiral Griffin says:

Unlike the tests that were made with Bering River coal last year, it was not necessary to hand-pick the Matanuska coal for the purpose of these tests. It was used in the same condition as when delivered, and the results are so satisfactory as to justify the belief that Matanuska coal is in all respects satisfactory for navy use, provided the coal tested is a thorough indication of the general character of the coal in the field.

Secretary Daniels said at a recent hearing that it compared favorably with the best steaming coal that the navy has, and that it was put down at 97 per cent. against 100 for the best coal.

Behavior of Riveted Joints under Stress*

By James E. Howard

The efficiencies of riveted joints under rupturing tensile stresses constitute the values on which working loads are commonly based. Alleged factors of safety are employed, fortunately not less than five on important work, because a fairly good distribution of load is not always characteristic of riveted construction. The most important feature, however, is in the elastic behavior of the joints, which appears to be ignored. As a matter of fact, few riveted structures are free locally from strains which do not exceed the elastic limit of the material. The structures are not necessarily endangered by the presence of such overstrains, as this will depend upon the character of the work to be performed. Multiple-riveted, double butt-strap joints may have a degree of rigidity equal to or even in excess of the solid plate for comparatively low tensile or compressive stresses, but loads ranging from, say, 15,000 to 25,000 lb. per sq.in. commonly show a material divergence in the behavior of a joint over that of the solid plate.

When frictional resistance contributes toward the initial rigidity of the joint, it is uncertain whether the favorable showing of the joint in the laboratory test is realized and maintained under service conditions. Vibratory effects and changes in temperature seem likely to cause a creeping of the plates and disturb the initial state of the different plies, when taken in conjunction with a constant load, or, it may be more marked, in the case of alternate stresses.

Referring specifically to the strength of those parts on which reliance is placed in the design of a riveted joint, first comes the tensile strength of the plate taken as a whole; next to this the strength of the steel between the rivet holes—that is, on the net section. On the latter section the strength per unit of area is not the same with different pitches. It may be greater or less than that accredited to the gross section per square inch It is also modified according to whether the holes are drilled or punched, and may be greater in one case or the other according to the distance from rivet hole to rivet hole. It is not likely that the strength with punched holes will be greater than with drilled holes in practice, since very closely pitched work is required to bring about such a result. The reason, however, that a punched plate may display greater strength than a drilled one is found in the hardening of the steel by the punch and die at the sides of the holes.

The tensile strength on the net section of the plate is usually greater than on a strip of uniform width several inches in length. The increased area of metal on each side of the center line passing through the rivet holes has a reinforcing effect on the net section of the plate. This gain in strength is a substantial one in single-riveted work, and in multiple riveting when the same pitch is maintained in the different rows. The reinforcement is greater in close-pitched than in wide-pitched riveting, and is at the sides of the holes, but if they are very far apart there results a loss instead of a gain. The reinforcement is therefore not a fixed amount, but depends upon the proportions of the joint.

When the pitch has been considerably increased, as in butt joints with double covers, in which one strap is considerably wider than the other, joints which fail by the rupture of the plate not infrequently show a diminution in strength on the net section, and the plate tears apart at the outside row of rivet holes. The presence of a few rivets, widely spaced, in the outside row promotes tearing of the plate, the line of rupture starting at a rivet hole and reaching an advanced stage before the plate at the middle of the pitch is separated.

Tests on staggered riveting have shown a tendency for the plate to draw down along shearing planes, obliquely to the direction of pull, encountering a rivet in the adjacent row. That is, the design of the joint was such that those in adjacent rows occupied critical positions with reference to each other, and while the zigzag path from one row to the other was longer than from rivet to rivet of the same row, nevertheless the plate showed a preference to fracture along this greater length, and the interposition of rivets in the second row in critical places was a probable source of weakness.

Chain-riveted work creates a favorable impression when observing and comparing the behavior of different types of joints under test. The distance between rows in chain riveting admits of being very much reduced over current practice without impairing the ultimate strength of the joint.

It will be of interest to refer to the strength of riveted joints at higher temperatures. Under exceptional circumstances the joints of steam boilers might be exposed to temperatures considerably above that due to the steam pressure. Joints have been tested up to a temperature of 700 deg. F., and the strength was found to follow the law which governs that of plain steel bars at different temperatures. There was a drop in strength at 200 deg., followed by an increase, which reached a maximum at about 500 deg., after which the strength fell off. Among the several joints tested at 500 deg. the maximum gain over the cold joints was 27.6 per cent. The shearing strength of the rivets showed an increase at the higher temperatures. Furthermore, it was found that joints which were overstrained at these higher temperatures, even beyond the limits of duplicate cold tests, when subsequently tested to destruction at ordinary temperatures, retained substantially the strength which they had when hot. There was some loss in the ductility of the steel, but without approaching a state of brittleness.

So much for the ultimate strength of riveted joints. Attention must be given the behavior of the joints under stress and whether the working loads are constant or variable, direct or reversed stresses, and in the case of repeated stresses, how many repetitions there will be and the maximum stresses involved. The examinations of some stress-strain curves prepared from earlier tests shows that the joints in general take a wide departure from the curve representing the solid plate, this being noticeable at 15,000 lb. per sq.in., and in some joints as early as at 10,000 lb. This was true with joints having efficiencies of 70 to 80 per cent. Among the joints thus compared were double- and triple-riveted butt joints and quintuple joints in which the inner butt strap was wider than the outer one.

Under 15,000 lb. per sq.in. the joints, in general, displayed an extension one and a half times to over twice the extension of the solid plate. These joints were of the types which are used in steam boiler construction. Observations on the behavior of double-riveted lap joints on some steam boilers which had been in service showed greater extension across the longitudinal seams at the middle of the sheets than in the vicinity of the girth seams.

It is of interest whether riveted seams retain their primitive state under prolonged service stresses or whether they do not slip and eventually display increased extensions under lower loads than suggested by the laboratory tests. From the limited number of observations made it cannot be said that the rigidity of joints on actual structures is greater than would be expected. If there is a difference, they are probably less rigid in actual structures.

The frictional resistance due to the shrinkage of the rivets is apparently a factor in the early behavior of a joint. Whether this force drawing the plates together is acting to its full extent will depend upon the manner in which the riveting is done. A limited range in temperature in cooling is sufficient to apply a contractile force equal to the elastic limit of the rivet metal. But since the hot rivet metal has a very low elastic limit it is necessary to hold the plates together firmly until the rivet has cooled to nearly its final temperature. This requirement is an obstacle to rapid driving, but full efficiency in frictional resistance between the plates requires its observance.

*From a paper presented at the twenty-second general meeting of the Society of Naval Architects and Marine Engineers.

BOOKS RECEIVED

CONCRETE PILE STANDARDS. By Huntley Abbott. Published by Huntley Abbott, 11 Pine St., New York City. Paper; 59 pages, 9x12 in.; illustrated. Price 50 cents.

DRAKE'S TELEPHONE HANDBOOK. By D. P. Moreton. Frederick J. Drake, Chicago, Ill. Cloth; 286 pages, 4x6½ in.; 161 illustrations. Price, $1.

A Coal Treatment Alleged to Be Advantageous—There has recently been in Germany quite a flood of preparations put upon the market for the purpose of making a brew in which coal or coke is to be wetted before being put upon the fire. The alleged result of using these preparations is that the coal burns more readily and that there is a great saving in the amount of fuel required. Herr T. Oryng, of the laboratory of the Berlin Fermentation Institute, has analyzed a number of these preparations and found them to consist of various salts, such as sulphate of magnesia, sulphate of soda, common salt, nitrate of soda, and so on, generally with a small proportion of oxide of iron. He concludes that they cannot have the effects attributed to them.—Foreign Exchange.

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POWER

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Create the Opportunity

THE *man who "makes good" usually has to create his own opportunity.*

□ □ □

We often hear it said: "Wait until the opportunity offers itself." Many men are still waiting. Many men will be waiting when they are old and gray.

We might as well say to a salesman: "Wait until business offers itself! Wait until business comes to you!"

The successful salesman is he who creates his own business; his own opportunity, in other words. He is the man who uses his head, and gets all there is out of his own faculties, education and energy.

In a like manner the successful engineer or the successful man in any other job is he who creates his own opportunity—make yourself so valuable to your employer that he cannot do without you.

When this point is reached you are on the road to advancement and success.

A man may arrive at his work before the whistle blows in the morning—he may not leave until after it blows at night.

Yet—he does not earn his salary if his mind is not on his job. And even if opportunity does knock at his door he will be asleep and it will pass on to the next fellow. But, *you* are as good as the next fellow if you only realize it.

Therefore:

Wake up! Put your mind to your work! Think! Be a little bigger than your job! Create an opportunity! You can do it—and the future will be bright and rosy.

[*Written by K B Lamb, New York City.*

Kalamazoo Municipal Plant

By Thomas Wilson

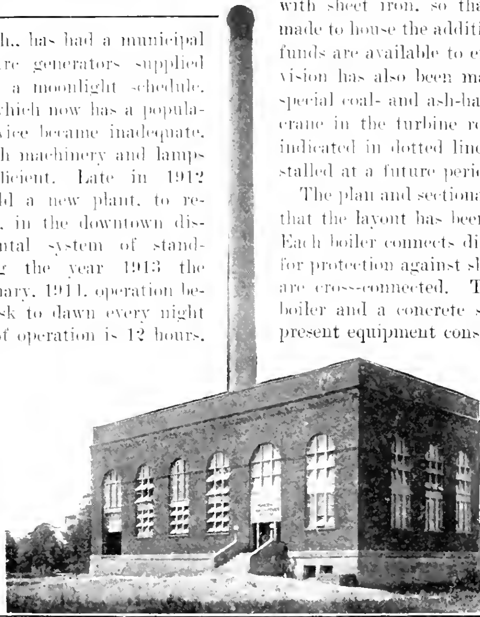
SYNOPSIS—Modern 1200-kw. plant, arranged on the unit plan, supplies current for street lighting and eventually will enter the commercial field. Cost of installation and operating expense. A feature is a provision to utilize auxiliary exhaust steam in the lower stages of the turbines.

Since 1895 Kalamazoo, Mich., has had a municipal plant for street lighting. Arc generators supplied about 100 lamps operated on a moonlight schedule. With the growth of the city, which now has a population of about 15,000, the service became inadequate, and after 17 years of use, both machinery and lamps were out of date and inefficient. Late in 1912 the city issued bonds to build a new plant, to rehabilitate the arc system and, in the downtown district, to install an ornamental system of standard five-light units. During the year 1913 the plant was erected and in February, 1914, operation began. The service is from dusk to dawn every night and the average daily period of operation is 12 hours.

The plant is near the Kalamazoo River, so that an abundant supply of cooling water is available for the condensers. As boiler feed it is used only when the city supply fails, as the river water is muddy and contains acid from the discharge of paper mills. A spur from the Michigan Central R.R. enters the property to facilitate coal delivery.

The exterior of the building (Fig. 1), which rests on concrete foundations, is built of brick supported by steel framework and is covered by a flat concrete roof. Its present dimensions are 52x100 ft. and one end is sealed with sheet iron, so that an extension may be easily made to house the additional equipment necessary when funds are available to enter the commercial field. Provision has also been made for overhead coal bunkers, special coal- and ash-handling systems and a traveling crane in the turbine room. These improvements are indicated in dotted lines in Fig. 5. They will be installed at a future period.

The plan and sectional elevation, Figs. 5 and 6, show that the layout has been arranged on the unit system. Each boiler connects directly with a turbine, although for protection against shutdown the steam-supply pipes are cross-connected. There is a feed pump for each boiler and a concrete stack serving both units. The present equipment consists of two boilers rated at 310 hp. each and two 600-kw. turbo-generators with their condensers and auxiliary equipment. For each kilowatt of turbine there is 0.52 boiler horsepower. At rating each turbine alone calls for 9720 lb. of steam per hour. The steam is supplied at 200 lb. gage pressure and an average



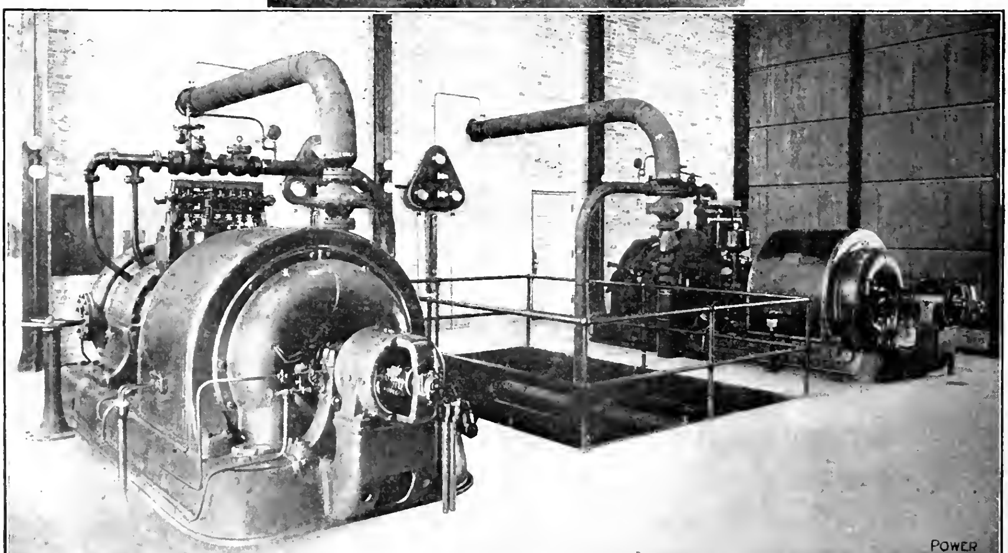


Fig. 1. Exterior of Kalamazoo Municipal Lighting Plant. Fig. 2. The Two 600-Kw. Generating Units

superheat of 150 deg. The cost of the installation is given in Table 1:

TABLE 1—COST OF STATION

Building, site and engineering fees	$40,384
Stack	2,850
Piping	5,686
Equipment	46,643
Total	$95,563

Cost per kilowatt of turbine capacity, $79.64.

The various items include all labor and installation charges, but the amount charged for equipment does not take into account the cost of rectifiers, lamps, or other apparatus belonging to the lighting system proper. Omitting the building and engineering fees, the cost per kilowatt reduces to $46. At present the building item is top-heavy, but the additional capacity soon to be installed will reduce the unit cost considerably.

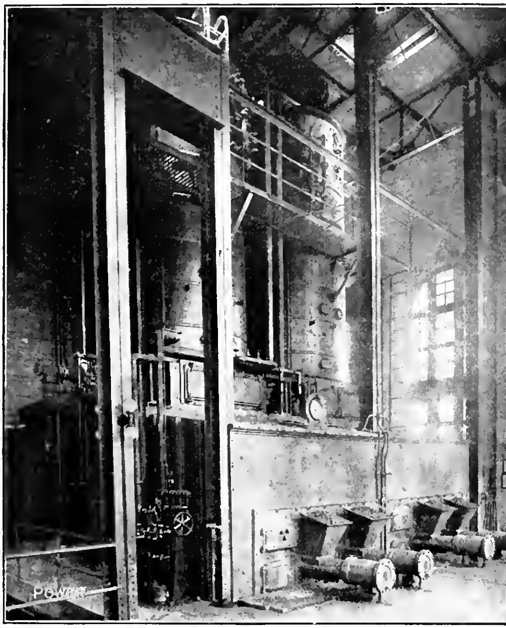


Fig. 3. Vertical Water-Tube Boilers and Underfeed Stokers

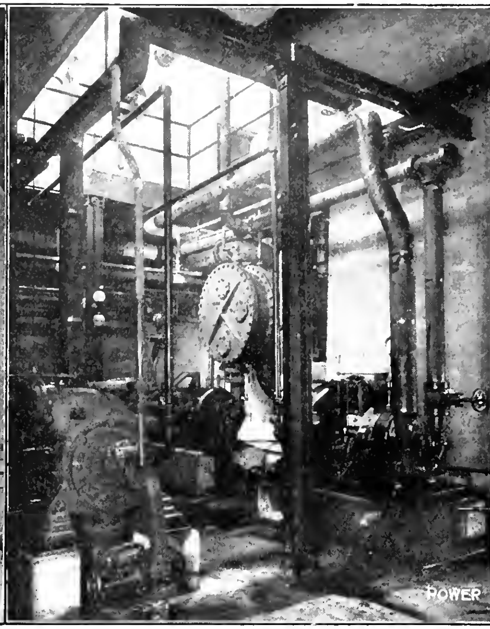


Fig. 4. Condenser Auxiliaries in the Condenser Pit

Boiler Room

Vertical water-tube boilers were selected. Each has 3089 sq.ft. of heating surface and 104 sq.ft. in the superheater. As shown in Fig. 3, underfeed stokers serve the boilers and forced draft is supplied by a 110-in., three-quarter-housed steel-plate fan driven by either one of two vertical engines, one on each side of the fan. The speed of these engines, and consequently the draft, is controlled indirectly by the steam pressure through automatic regulators. The stack rises 145 ft. above the boiler-room floor. The inside diameter at the bottom is 8 ft. and a taper of 1 in. to every 5 ft. reduces it at the top to 5 ft. 6 in.

At present the coal is stored in a temporary shed. It is loaded into a car which passes over a platform scale on its way to the stokers. The ashes are wheeled out and disposed of on the premises. Much better facilities have been provided for the ultimate construction. The plant is to have a wet coal storage into which the coal will be dumped from railroad cars. A gantry crane with a grab bucket will pick up the coal and deliver it through the roof into overhead coal bunkers, each having a capacity of 85 tons. Automatic scales and a chute to each stoker hopper will complete the equipment. Ashes will be discharged into a hopper underneath the boiler-room floor thence into an ash car. The latter will be wheeled to the end of the building, raised by a hydraulic hoist to the first floor and its contents will be delivered to a section of the coal-storage pit reserved for the purpose. The crane can then be used to load the ash into the cars which deliver the coal.

West Virginia slack averaging about 13,000 B.t.u. per lb. is the fuel burned. It is bought on the B.t.u. basis established by the Bureau of Mines and the cost is close to $2.50 per short ton.

Generating Units

Horizontal four-stage turbines of the velocity type drive three-phase, four-wire generators at a speed of 3600 r.p.m. (Fig. 2). Sixty-cycle current is supplied at a voltage of 2300 or 4000, and the rating of the turbines at 80 per cent. power factor is 600 kw.

The steam-supply pipes to the turbines are 5-in. diameter, and with a rate of 16.2 lb. per kw.-hr. at normal load, 9720 lb. of steam per hr., or 162 lb. per min., must flow to the turbine. At 200 lb. gage pressure and 150 deg. superheat, the volume of this amount of steam is 434.16 cu.ft. The velocity of the steam in the supply pipe is then

$$434.16 \div 0.1389 = 3126 \ ft.$$

or, in round numbers, 3100 ft. per min. For a turbine this velocity is low. A supply velocity of 8000 ft. per min. is not uncommon in the present-day practice. A smaller supply pipe could have been used, but in the present case the saving in first cost would have been negligible.

Each turbine is served by a three-pass surface condenser having 1600 sq.ft. of surface. This is an allowance of a 16-hp. turbine at 4000 r.p.m. and a 7-in. circulating pump capable of delivering 1200 gal. per min. The latter is driven by a 25-hp., 440-volt motor which receives its current from the generator leads through a step-down transformer. This connection was made to facilitate starting and to insure the presence of cooling water as

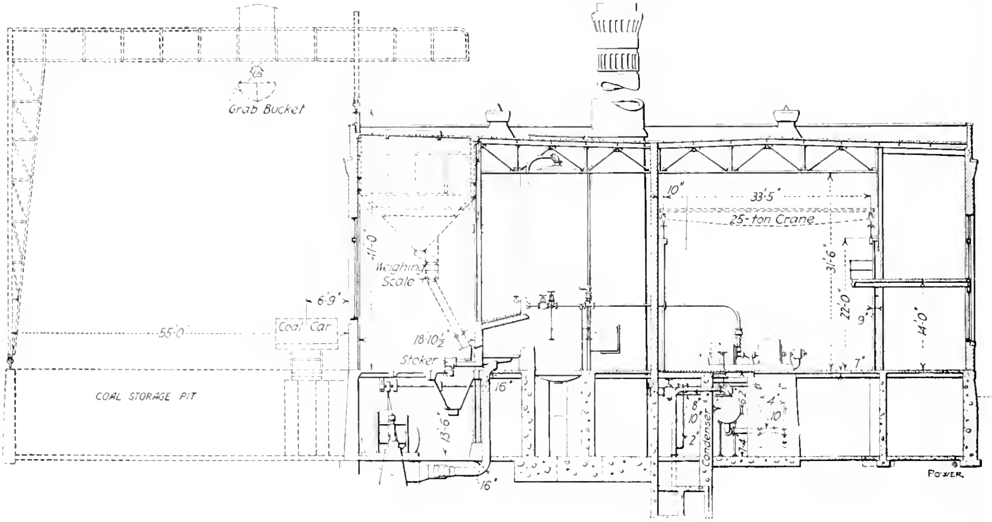


FIG. 5. SECTIONAL ELEVATION THROUGH STATION, SHOWING PROPOSED COAL- AND ASH-HANDLING FACILITIES

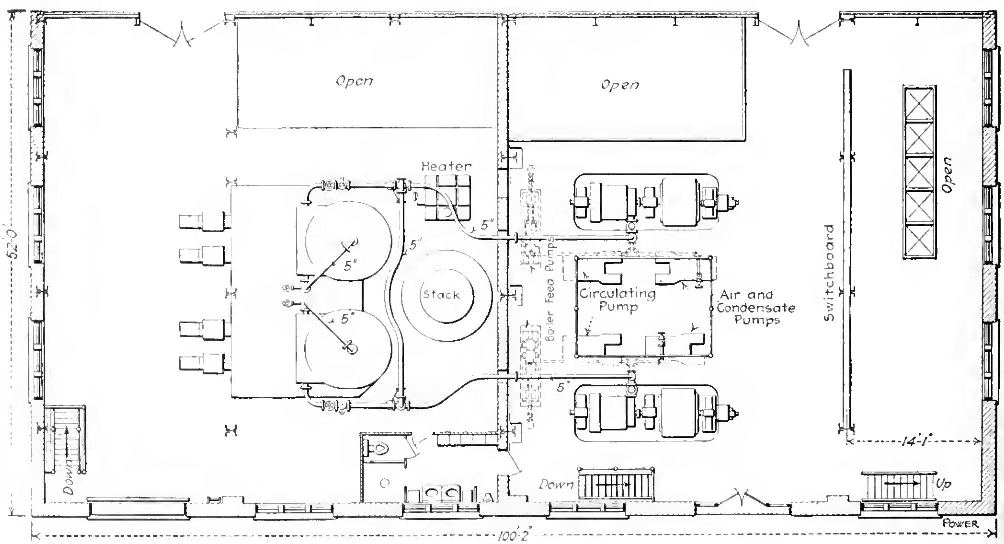


FIG. 6. PLAN OF THE STATION

$2\frac{2}{3}$ sq.ft. of surface per kilowatt of turbine rating. At 28-in. vacuum and with 75-deg. cooling water, the condenser is guaranteed to care for 8500 lb. of steam per hr. This reduces to 5.3 lb. of steam per sq.ft. of condensing surface. The auxiliaries (Fig. 4) are a combined air and condensate pump of the radial jet type driven by soon as the main unit is put into operation. It was thought that one steam and one electrically driven auxiliary would make a more flexible outfit than two similar units. From the feed pumps, stokers, fan engines and the turbines operating the air pumps there would be more than enough exhaust steam to heat the feed water, and turbine-driven circulating pumps would only increase the surplus.

Turning Exhaust Steam into Turbines

To utilize the exhaust steam from the sources just mentioned to best advantage, the ingenious plan shown in Fig. 7 has been adopted. Each of the steam-using auxiliaries discharges into a common exhaust system which enters the feed-water heater and is also tapped into the fourth stages of the main turbines. To the latter automatic regulating valves control the supply, and check valves prevent steam flowing from the turbines to the exhaust system. The heater uses as much steam as it requires. Any excess builds up the pressure in the system, and when it exceeds the pressure at the points of entrance to the turbines, the automatic valves open and admit the surplus. This usually occurs when the turbine is carrying a light load. A back-pressure valve opening to the atmosphere protects the system.

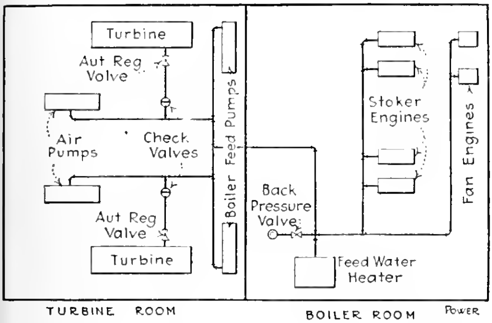


Fig. 7. Piping for Utilizing Exhaust Steam

In another plant this idea has been completed by the same engineers so that exhaust steam may enter the turbine or steam may pass from the turbine to the exhaust system, depending on the relative pressures. The connections are shown diagrammatically in Fig. 8. Two back-pressure valves are employed. The one at *A* opens toward the turbine and valve *B* toward the exhaust system. These valves are set at approximately 2 lb. pressure. If the turbine is heavily loaded and the pressure at the point of entrance is relatively high, valve *A* must remain closed and valve *B* will admit steam to the system. With conditions reversed and the pressure greater in the system, valve *A* opens and admits steam to the turbine. As usual, an atmospheric relief valve set at a higher pressure than the other valves, affords protection against a possible emergency.

Switchboard and Line

Fig. 9 shows the front of the switchboard, which has 11 black-slate panels and four double blue Vermont arc panels set out 14 ft. from the wall. The board is equipped with the latest instruments and provides for remote control. Back of the board are the oil switches, instrument transformers, etc., mounted on pipe framework, and four of the mercury arc rectifiers. There is a total of eight 75-light outfits, four being in the basement. It will be noticed in Fig. 10 that the wiring is unusually neat and accessible and that there are free passageways immediately behind the board and between the switches. Fig. 11 is a view in the basement showing rectifiers, cut-outs and the entrance of the cables into the underground ducts. About 225 ft. from the station the cables are brought up through iron-pipe risers to a terminal tower and by means of flexible jumpers are connected to the pole line leads.

The 534 luminous arc lamps, each taking 4 amp. at 80 volts, are hung on 12-ft. mast arms and are equipped with a special cutout to protect the trimmer against the high voltage of the circuits. These arcs serve the residence district, the business center being lighted by 234 ornamental five-light posts spaced 75 ft. apart on both sides of the streets. The top lamp of each cluster is rated at 100 watts and the four side lamps take 60 watts each. For the illumination of alleys there are 41 four-ampere tungsten lamps. The city hall is also lighted by the plant.

Operating Costs

As previously stated, the plant is operated from dusk to dawn every night in the year, irrespective of the phase of the moon. One boiler is banked through the day, but two shifts of employees are required. Seven men are employed in the plant—one chief engineer, two assistant engineers, two firemen and two day men. The period of daily operation averages 12 hr. and as the entire load is lighting, it remains practically constant. Up to midnight the load averages 280 kw. The lower lamps of the ornamental clusters are then cut out and the load drops to 230 kw. The total kilowatt-hours for the night, then, average 3060. In this, however, the current for the air-pump motors is not included, as the supply to these motors is tapped directly from the generator leads and is not metered.

On an average from Apr. 1 to Sept. 1, 5.85 tons of coal were burned per night; from start to midnight, 5800 lb.:

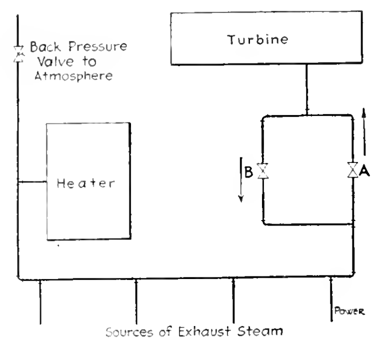


Fig. 8. Improved Arrangement Allowing Steam to Flow to or from the Turbine

from midnight to shutdown, 4800 lb., and 1100 lb. were required for banking. This is an average of 3.82 lb. per net kilowatt-hour. In the above period, containing 153 days, the total money spent on the plant for coal, labor, supplies, etc., was $7249. This figures $47.38 per day, and dividing by the output gives an operating cost of 1.55c. per kilowatt-hour. A fixed charge of 12 per cent. for interest, depreciation, taxes and insurance on an investment of $95,563, the total cost of the plant, amounts to $11,467.56 per year, or $31.42 per day, and, based on the present net load, 1.02c. per kw.-hr. Adding the operat-

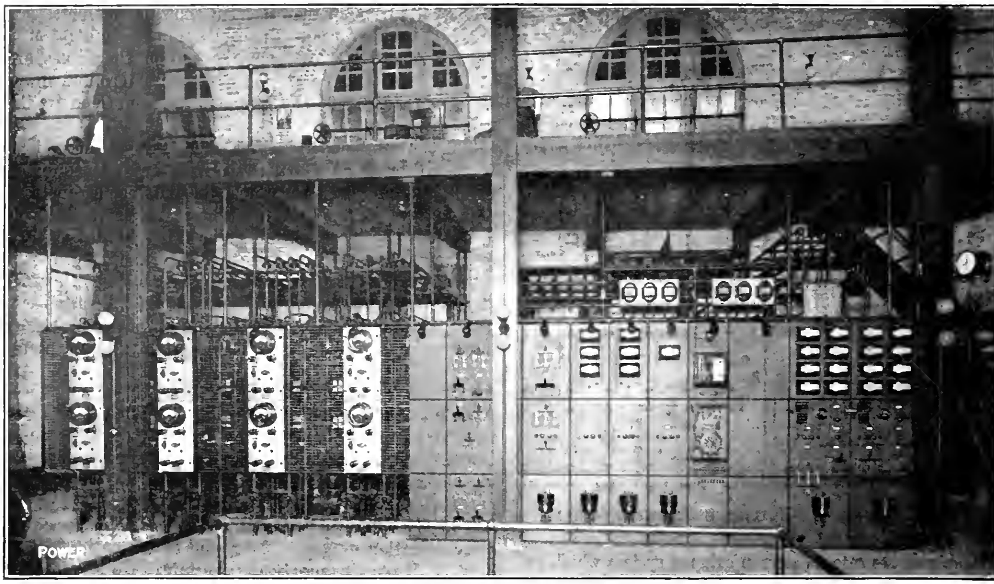


FIG. 9. FRONT VIEW OF SWITCHBOARD AND ARC PANELS

ing and fixed charges gives a total cost of 2.57c. per kw.-hr.

As might naturally be expected, the cost of putting a kilowatt-hour on the line is high, but considering the conditions, the showing is excellent. The plant was designed for a much larger load than it is now carrying, and

TABLE 2—RESULTS OF TESTS ON BOILERS

	Boiler No. 1	Boiler No. 2
Total Quantities, Lb.—		
Total water evap., corrected for losses, lb.	67,054.00	70,938.00
Total coal fired, lb.	8,911.00	9,193.00
Total refuse, lb.	912.00	953.00
Total ash in refuse, computed from analysis, lb.	830.00	867.50
Total combustible in refuse, computed from analysis, lb.	82.00	85.50
Total equiv. water evap. into dry steam f. and a. 212 deg. F	75,905.00	83,281.00
Temperature, Deg. F.—		
Av. temp. of feed water	200.50	198.80
Av. temp. of steam at superheat outlet.	502.00	544.20
Av. superheat	120.00	162.20
Av. temp. of flue gases	501.00	495.50
Pressures—		
Av. steam pressure, gage, lb. per sq.in.	194.70	197.40
Av. steam pressure, absolute, lb. per sq.in.	209.40	212.10
Flue Gases—		
Av. CO_2 contents of flue gases, per cent	9.50	11.50
Av. CO contents of flue gases, per cent	0.70	0.50
Av. O contents of flue gases, per cent	6.00	3.00
Coal—		
Moisture in coal, per cent	4.42	
Volatile matter in coal, per cent	32.24	
Fixed carbon in coal, per cent	52.98	
Ash in coal, per cent	10.36	
Sulphur in coal, per cent	0.90	
B.t.u. per pound of dry coal	13,245	
Ash—		
Ash, per cent	91.32	
Volatile combustible matter and fixed carbon, per cent	8.68	
Capacity—		
Maximum hp. developed	300	300
Rated hp.	310	310
Av. hp. developed	225	225
Evaporation—		
Water evap. per lb. of coal as fired, lb.	7.53	7.71
Equiv. evap. f. and a. 212 deg. per lb. of coal as fired	8.52	9.11
Equiv. evap. f. and a. 212 deg. F. per lb. of dry coal	8.90	9.52
Equiv. evap. f. and a. 212 deg. F. per lb. of combustible	10.47	11.20
Efficiencies—		
Efficiency of boiler, furnace and superheater, based on dry coal, per cent	65.20	70.00
Efficiency of boiler, furnace and superheater, based on combustible, per cent	76.70	82.35
Loss of combustible, per cent. of coal fired	0.91	0.91
Heat Balance—		
Heat value of fuel utilized, per cent	65.20	70.00
Heat value of fuel lost, per cent	0.91	0.91
Heat lost by radiation, conduction and in stack, per cent	33.89	29.19

TABLE 3—RESULTS OF TESTS ON GENERATING UNITS

	Approximate Load on Turbine, KW.		
Total Quantities—	600	450	300
Weight of condensate, including leakage, lb.	48,256.0	15,057.0	7,811.0
Actual steam consumption, corrected for leakage, lb.	46,971.0	14,476.0	7,425.0
Total energy generated by generator, kw.-hr.	3,070.0	940.0	450.0
Hourly Quantities—			
Leakage per hour		257.0	
Av. power developed by turbine, kw.	614.0	425.0	300.0
Average Temperatures, Deg. F.—			
Av. temp. of room at mercury column		78.5	
Av. temp. of steam (superheated) at throttle		540.6	
Av. temp. of steam (saturated) at throttle		380.6	
Av. deg. of superheat		160.0	
Av. temp. in exhaust nozzle of turbine		74.5	
Temp. due to av. vacuum in exhaust nozzle		82.0	
Av. temp. of condensate		72.5	
Av. temp. of circulating water intake		59.5	
Av. temp. of circulating water, discharge		69.5	
Average Pressures—			
Av. pres. of steam at throttle, gage, lb.		196.0	
Av. pres. of steam at throttle, absolute, lb.		210.7	
Av. vacuum in exhaust nozzle, in. hg. (corr. for temp.)		28.5	
Av. reading of barometer, in. hg. (corr. for temp.)		29.6	
Av. abs. press. in exhaust nozzle, in. hg.		1.1	
Av. abs. press. in exhaust nozzle, lb. sq.in.		0.54	
Economic Results—			
Actual consumption of steam per kw.-hr., lb.	15.3	15.4	16.5
Consumption of steam per kw.-hr. (corr. for conditions of steam and vacuum upon which guarantees are based), lb.	15.9	16.0	17.1
Guaranteed consumption of steam per kw.-hr. (based on 200 lb. gage press., 150 deg. superheat at throttle. Abs. back pressure 2 in. hg.), lb.	16.2	16.2	17.4
Consumption of coal, lb. per kw.-hr.:			
(a) Turbine without auxiliaries		2.07	
(b) Turbine with auxiliaries		2.31	

as soon as the city enters the commercial field, it is expected that additional generating capacity will be required. At present only one unit is maintained in operation at less than half load for 12 hr. out of the 24. The overhead expense imposes a heavy burden on small output. The double shifts make the labor cost high, and coal for banking adds to the fuel cost. With a commercial load requiring current during the day, the plant would be kept in continuous operation and the generating units would be operated at about rated capacity. There would be less loss from banking the fires and some returns for the work of the day shift. The total output would be much larger at but little additional expense, so that the cost per unit would be greatly reduced.

is not as high as might be expected, but is attributed to the fact that the boiler was started cold, so that a certain amount of the fuel was required to heat up the setting. The efficiency of 70 per cent. obtained on No. 2 boiler is good, considering the fuel burned, which is West Virginia slack of the analysis given in the table.

The results of the tests on one of the generating units are given in Table 3. The duration of the tests was 8 hr.: 5 hr. at full load, 2 hr. at three-quarter load and 1½ hr. at one-half load. At half load the electrical energy was absorbed in the lighting circuits normally supplied from the generators. For the higher loads a water rheostat was used. The coal consumption during the tests was 2.31 lb. per kw.-hr., as compared to 3.82 lb. obtained

PRINCIPAL EQUIPMENT OF KALAMAZOO MUNICIPAL PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
	Boilers	Vertical water-tube	310 hp.	Steam generators	200 lb press., 150 deg superheat	Wickes Boiler Co.
2	Stokers	Jones underfeed		Under boilers	Controlled by Cole automatics.	The Under Feed Stoker Co. of America
2						
2	Superheaters	Foster	104 sq.ft	Superheat steam	Av. superheat, 150 deg	Power Specialty Co.
1	Fan	¾ housed	140 in. dia.	Draft for boiler furnace	Driven by either of two 5x7-in Troy eng.	The Under Feed Stoker Co. of America
1	Heater	Open	1500 hp.	Heat boiler feed water	750 lb water per min. from 50 deg	Warren Webster & Co.
2	Pumps	Duplex	7½x4½x10-in	Boiler feed water	200 lb steam.	Henry R. Worthington
2	Turbines	Hor. vel. type, 4-stage	600 kw.	Main units	200 lb press., 150 deg. superheat, 3600 r.p.m.	General Electric Co.
2	Generators	Three-phase, 4-wire	600 kw.	Main units	2300 4000-volt, 60-cycle, 3600 r.p.m.	General Electric Co.
2	Exciters	Direct-current	7 kw.	Excite main units.	Mounted on shaft of main unit	General Electric Co.
2	Condensers	Surface, 3 pass	1600 sq.ft.	Serve main units.	Cooling water from river	Wheeler Condenser & Engineering Co.
2	Pumps	Turbo air and condensate	No. 10	Serve condensers	Driven by 16-hp Terry turbines, 4000 r.p.m.	Wheeler Condenser & Engineering Co.
2	Pumps	Centrifugal	7-in.	Condenser circulating water	Driven by 25-hp. G E. 440-v. motor, 900 r.p.m.	Wheeler Condenser & Engineering Co
	Switchboard, rectifiers, lamps and line equipment.					Genera E ectric Co

The fuel cost per unit is one of the best indications of plant economy. In the present instance this item approximates ½c. per kw.-hr. For the conditions (coal costing $2.70 per ton, only one unit running and at less than half load, and nearly 20 per cent. of the coal used for banking) this cost is low. It compares favorably with plants of the same or greater capacity running at full load, and indicates what may be expected of the present plant when it is operated under favorable conditions.

Official Tests

That the plant is efficient is shown by the results of the official tests made on May 15 and 16 of this year by representatives of the consulting engineers and the city. Table 2 gives the results of the boiler tests, each of 8-hr. duration. An efficiency of 65.2 per cent. for boiler No. 1

under the present unfavorable operating conditions. The steam consumption at full load was found to be 15.3 lb. per kw.-hr., and when corrected to the guaranteed conditions of 200 lb. steam pressure, 150 deg. superheat and an absolute back pressure of 2 in. of mercury, was 16.2 lb.

The coal burned under the boilers had an average heat value of 12,650 B.t.u. per lb., as fired. An average of 2.31 lb. was required per kilowatt-hour, so that the total heat expended under the boiler to generate a unit of electrical energy was

$$2.31 \times 12{,}650 = 29{,}221.5 \textit{ B.t.u.}$$

One kilowatt-hour is equal to 3412 B.t.u., so that the thermal efficiency of the generating plant is

$$\frac{3412}{29{,}221.5} = 11.67 \textit{ per cent.}$$

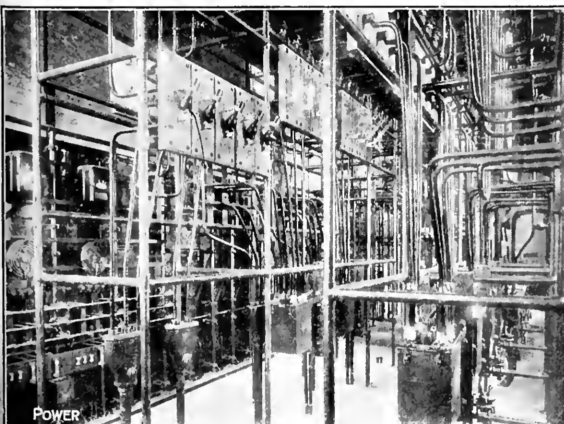


Fig. 10. Switching Chamber at Rear of Board

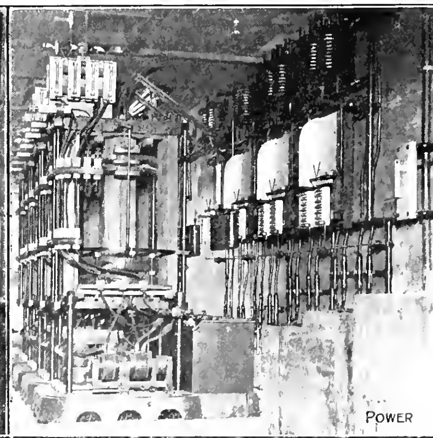


Fig. 11. Rectifiers in Basement and Equipment Protecting Line

For any steam plant of the type and capacity, this is as high a thermal efficiency as can be expected.

It is evident that the plant is uptodate in every respect and can be operated at high efficiency. To reduce the present unit cost, it is merely a question of obtaining enough commercial service to properly load the plant.

E. W. Messany is chief engineer of the plant, and Woodmansee & Davidson, of Chicago, were the consulting engineers responsible for the design and construction of the station.

Return-Pipe Compressed-Air Practice

By Frank Richards

A letter from a California correspondent asks why it is that more has not been made of the Cummings system of compressed-air power transmission. He says that from the results which have been actually attained by the system it could be advantageously employed in many places, especially as, besides the economy of it, there is no danger of fire or explosion, and it can be operated under water.

Notwithstanding that the return-air or two-pipe pumping system, for raising water by the direct pressure of air, is quite extensively and successfully employed in different parts of the country, and that this system has been fully described in various publications, the essential principles of the Cummings system in its entirety are not generally well understood even where it happens to be known at all. Patented a full generation ago, it seems to have been exploited mostly in California, and it may be worth while to call the attention of power users to it again.

It is rather curious that the new departure which this system represents—the use of higher pressures—is quite in line with the improvements in steam engines, in oil engines, especially of the Diesel type, and in electrical practice. It may be claimed, however, that the two-pipe

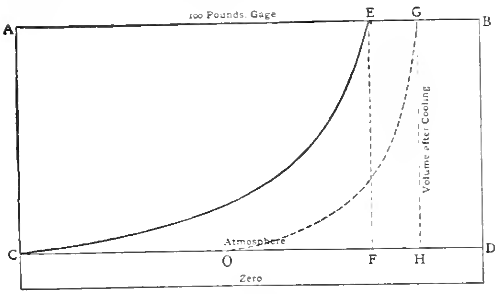


Fig. 1. Air between 0 and 100 Lb. Gage

air system "goes them one better." In the compound- or the triple-expansion steam engine it seems to be the last added portion of the pressure which secures the economy, but the entire range of the pressure from the bottom to the top has all been retained, while the compressed-air system here to be spoken of retains and uses only the higher, and presumably more profitable, range of pressure.

The essential feature of the system is the constant maintenance of a high pressure upon the air employed. Instead of continually compressing fresh atmospheric air up to, say 100 lb. gage, using it in the motor at that pressure, with or without expansion, and then exhausting the air into the atmosphere again, a constant intake pressure of, say 100 lb. is maintained at the compressor. The air is compressed to, say 200 lb., is transmitted to and is used in the motor at that pressure, and then is exhausted and carried back to the compressor at a pressure of 100 lb., to be compressed and used again, and so on.

Different Pressure Ranges Compared

The accompanying diagrams, Figs. 1, 2, 3, are all drawn to the same scale for equitable comparison, and may be studied together, although each represents an operation entirely distinct from and unrelated to the others; that is, they are not successive stages of one operation. In each case the same volume of air fills the cylinder at the beginning of the compression, but the actual weights

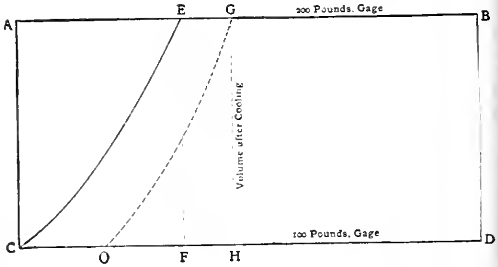


Fig. 2. Air between 100 and 200 Lb. Gage

or quantities of air are very different, only Fig. 1 beginning the compression with "free air," or air at atmospheric pressure.

Fig. 1 represents the adiabatic compression of a given volume of air from atmospheric pressure, say 15 lb. to the inch absolute, to a gage pressure of 100 lb., or 115 lb. absolute. Fig. 2 shows the compression of an equal volume (not an equal weight) of air, but under an initial pressure of 100 lb. gage, to a delivery pressure of 200 lb.; and in Fig. 3 an equal volume of air at 200 lb. is compressed to 300 lb.

In each case the initial volume of air compressed is represented by the area of the rectangle *ABDCA*. When the air has been compressed to the gage pressure specified in each case its volume is represented by the area *EBDFE*, and this will be the volume assumed to be discharged into the pipes and receiver. As we are speaking now from the purely theoretical viewpoint, nothing is said about clearance or other allowances made in practice.

It is well understood that the operation of compression invariably increases the temperature of the air very much, but this temperature it is impossible to maintain, and unless reheating is employed, the air is never used at the high temperature at which it is delivered by the compressor. As the air cools to normal temperature before it is used, its volume being reduced proportionately, the actual volume available for use is represented by the area *GBDHG*, this being in Fig. 1 only about an eighth of the initial volume, and not much more than one-half the volume *EBDFE*, as delivered by the compressor.

The air delivered under either compression represented may be said to have equal working value, volume for volume, the available pressure being 100 lb. in either case, the air in Fig. 1 at 100 lb. working against atmosphere only, the air in Fig. 2 at 200 lb. working against a back pressure in the return pipe of 100 lb., and that in Fig. 3 at 300 having a back pressure of 200 lb.

In compressing air from 100 to 200 lb., as in Fig. 2, the temperature of the air is not raised nearly as much as in Fig. 1 and, consequently, the shrinkage in cooling from volume *EBDFE* to volume *GBDHG* is proportionately much less than in Fig. 1. The volume *GBDHG* here

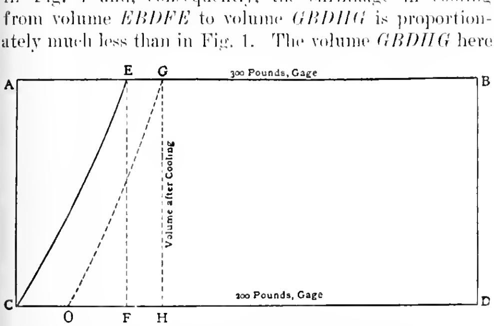


FIG. 3. AIR BETWEEN 200 AND 300 LB. GAGE

available for work is more than one-half the initial volume *ABDCA*, or four times the volume available in Fig. 1. At the same time it is to be noted that the mean effective pressure in the compressor cylinder for the stroke, which is the measure of the actual work of compression, is decidedly less than double that of Fig. 1. Getting fully four times the available volume for less than double the power employed certainly looks like doubling the efficiency by halving the relative cost of the compression.

In Fig. 3, compressing the air from 200 to 300 lb., the heating of the air is still less and the consequent shrinkage by cooling also is less. The available volume delivered, *GBDFG*, is five times the corresponding volume in Fig. 1, while the mean effective pressure required for the compression and delivery of the air is less than 2.1 times as much, which seems to be decidedly more than doubling the efficiency.

It has been assumed in each case above that the initial air temperature is 60 deg. F. With the same increase of 100 lb. in pressure the final temperatures will be 485, 163 and 121 deg., the rise of temperature being, respectively, 425, 103 and 61 deg. The enormous rise of temperature in compressing from atmospheric pressure has led to the general adoption of two-stage compression, with intercooling of the air, thereby gaining something in economy, avoiding the overheating of the surfaces, the burning of the lubricants and the danger of fires and explosions. With the heating that occurs in Figs. 2 and 3 there is no necessity for employing the two-stage compressor, and little possibility of any increased economy through its employment.

The ratio of final and initial absolute pressures is: In Fig. 1, 7.666; in Fig. 2, 1.869; in Fig. 3, 1.465. The ratio of the volume after cooling to 60 deg., or the volume available for use, to the initial volume is: In Fig. 1, 0.1304; in Fig. 2, 0.535 and in Fig. 3, 0.6825. The relative costs of compression, as measured by the power used, or the mean effective pressures for the compression divided by the volume after cooling, are: In Fig. 1, $11.6 \div 0.1304 = 319$; in Fig. 2, $78.88 \div 0.535 = 147$; and in Fig. 3, $86.83 \div 0.6825 = 127$. Here the ratio of the cost in Fig. 1 is $319 \div 147 = 2.17$, and of Fig. 1 to Fig. 3 it is $319 \div 127 = 2.51$.

It is understood that wherever this air is used—that is, the air of Fig. 2 and Fig. 3—whether for driving a rock drill, for a steam pump or an air motor of any kind, the air instead of being discharged into the atmosphere, as it would be from Fig. 1, is piped back to the compressor with only 100 lb. of its pressure used; then, volume for volume, the air used would be of the same power value in either case, if not used expansively. As the available volume delivered as shown in Fig. 2 is four times that in Fig. 1, a compressor of one-fourth the capacity, or, at equal piston speeds, with a cylinder one-half the diameter, will be sufficient for the work. The maximum unbalanced pressure against the piston would be no greater in one case than in the other, only it would be continued for a longer or a shorter portion of the stroke. There would be no additional strength required in any of the working parts of the machine, except that the air cylinder and connections would have to be strong enough for the maximum pressure.

As the same air is used over and over again in the two-pipe system, arrangements being provided for making up leakage losses, there is no appreciable accumulation of moisture and no possibility of freezing up, even if sufficiently low temperatures should occur, which they do not. At the same time more or less of the lubricant is carried back and forth in the air and comes in contact with the working surfaces. As the system is a closed one, being entirely out of touch with the surrounding atmosphere and not affected by the local pressure, it will work at one altitude just as well as at another.

WHY THE SYSTEM'S USE HAS BEEN LIMITED

Now as to why the system has not been more extensively employed; there is the fact to begin with that even yet it is not generally as well known and understood as it should be. Then, evidently, it would not be likely to be much used for intermittent work, such as the driving of rock drills which are continually changing their location, and where the maintenance of the return connection would cost in time and trouble enough to cancel the prospective advantage.

Apparently, the best employment of the system would be for the driving of ordinary steam pumps where constant pressure is usually required for practically the entire stroke. The air of Fig. 2, at 200 lb. pressure and 100 lb. back pressure, or the air at the higher pressures of Fig. 3 does not permit much profitable expansion in use. When used for rotative purposes in an engine or motor, the cutoff, as the compression diagram suggests, should never occur earlier than three-quarter stroke, so that the cutoff that may be accomplished by a good slide-valve engine would be all that would be available in any case. In this respect the air in Fig. 1 would have some advantage, as, to secure the greatest economy, it should be cut off before half-stroke, and a certain saving would be accomplished by the expansion which would not be possible where the higher pressures were employed.

There is a necessity for the compressor supplying the air and the engine or motor using the air to approximately keep pace with each other, not necessarily stroke for stroke, but so that, with the aid of suitable receiver capacity, the delivery and the return air pressures shall be maintained as constant as possible. This implies that the two working units of the system should be adapted to each other in capacity and that an automatic pressure governor should control the compressor.

A Gas-Tractor Power Plant

By C. V. Hull

SYNOPSIS—Description of the growth and development of a novel power plant in which the gas tractors under test are employed to furnish electricity for the factory.

One of the manufacturers of gas tractors has an unusual power plant. Power is furnished by the tractors under test, which are belted to 220-volt generators operated in parallel. A three-wire system with balancer set is used for current distribution. The growth of this plant has been rapid and the changes in its development are interesting.

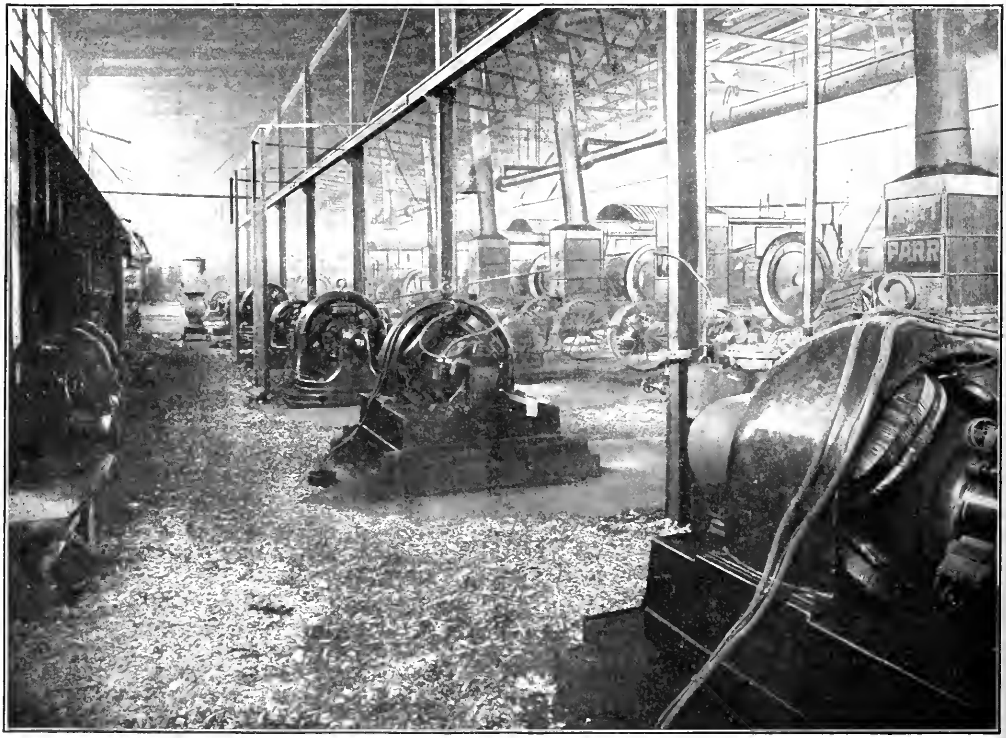


Fig. 1. Tractors Driving Generators

In the first plant power was furnished by a stationary engine belted to the line-shaft. This worked nicely until the buildings were enlarged and more machinery put in. It was then decided to use the tractors under test to drive 110-volt generators. Accordingly, a small power house was erected and one 110-volt generator installed. Some of the machines in the shop were motor-equipped, while others were belt-driven from lineshafts which were motor-driven.

With this plan the tractors were worked out in the yard and as soon as they were fit went into the power house to undergo a thorough test while furnishing power. As there was but one generator, tractors were generally changed during the noon hour. Shutdowns during shop hours came quite often, but the force was small at this time and there was no great loss.

The increasing demand for power soon made it necessary to install the second 110-volt generator. The two-wire system was continued, using the two generators in parallel. This made it possible to test two tractors at the same time and to change an engine without "dropping the load." There were times, of course, when a temporary heavy load caused a delay in changing engines.

The further demand for power was met by a third generator. It was then decided to change the distribution, using a three-wire system with two of the generators running in parallel. When the load was not too heavy only two of the three generators were run on the three-wire system. This allowed the use of 110- and 220-volt circuits at all times. The machines and lights were so connected that most of the 110-volt load was on one side of the system; hence the two machines in parallel carried considerably more than half of the load.

In order that any of the three generators might be used alone, double-throw switches were installed on the switchboard. By means of these switches, any two of the generators could be operated in parallel, with the third one running on the opposite side of the three-wire system. These generators were all compound-wound, but switches were put on them so that the series windings of the fields might be short-circuited when they were running in parallel.

When one of these generators played out, a three-wire machine was tried with indifferent success, and it was soon replaced with another 110-volt generator.

Usually, three dynamos were run during the day and up to 8 p.m., after which only two generators were used. In order to equalize the load after 8 p.m., one of the large 110-volt motors was fed by an individual circuit through a double-pole double-throw switch. When the three dynamos were in use this motor was fed from the two in parallel on the positive side, and when only two generators were running the motor was usually switched to the negative side to more nearly balance the load.

A single-pole double-throw switch was installed in the machine shop, so that an incandescent light circuit of some size could be switched as required. When this switch *S*, Fig. 2, was thrown to the right, the lights were on a two-wire circuit connected to the two dynamos in parallel. After 8 p.m. this switch was closed to the left, and the lights became a part of the three-wire system. All arc lamps were connected between the positive and neutral wires of the three-wire system, and the polarity of their supply was not changed.

When the motor and lights were switched to the negative side the load was nearly balanced.

The next addition was a larger 110-volt dynamo, of 600-amp. capacity (not shown in Fig. 2) for use with some 80-hp. tractors, although other tractors were used with it as well.

Soon after this, two 200-amp. dynamos were also installed in one end of the machine shop. These were arranged to be driven by one engine by the use of a double pulley on the first dynamo. They were also connected with double-throw switches so that they could be used in parallel or to feed the three-wire system. This outfit was very convenient, for small loads could be carried and it helped to keep the voltage quite steady when used to feed the three-wire system. After putting these machines in circuit all the dynamos were run with the shunt fields only.

Rapid increase in production, however, demanded more power, and it was decided that a new power house should be built and that 220-volt generators, with a balancer set, should be used.

It was not possible to get the power house ready for some time, so machines Nos. 1, 2, 3, 5 and 6 and two 220-volt dynamos, Nos. 7 and 8, were used for a considerable period. It was always necessary to start the 110-volt units first and then cut in the 220-volt machines. The double unit (5 and 6) was always cut in "against itself" (on opposite sides of the three-wire system) to prevent any possibility of mistake with 1, 2 and 3. One of the 220-volt dynamos was set up in the yard under a temporary shed, but whenever it rained the belt had to be removed. A temporary switchboard was set up in the new power house, and the other 220-volt machine was installed there.

It was a rather mixed-up power plant during the period just before the change-over. In the old power house there were three 110-volt dynamos and in the yard one 220-volt machine; in the machine shop were the big 110-volt dynamo, one 220-volt dynamo and the two 110-volt machines, combined in one unit. Two 220-volt dynamos were next set up in the new power house with a tem-

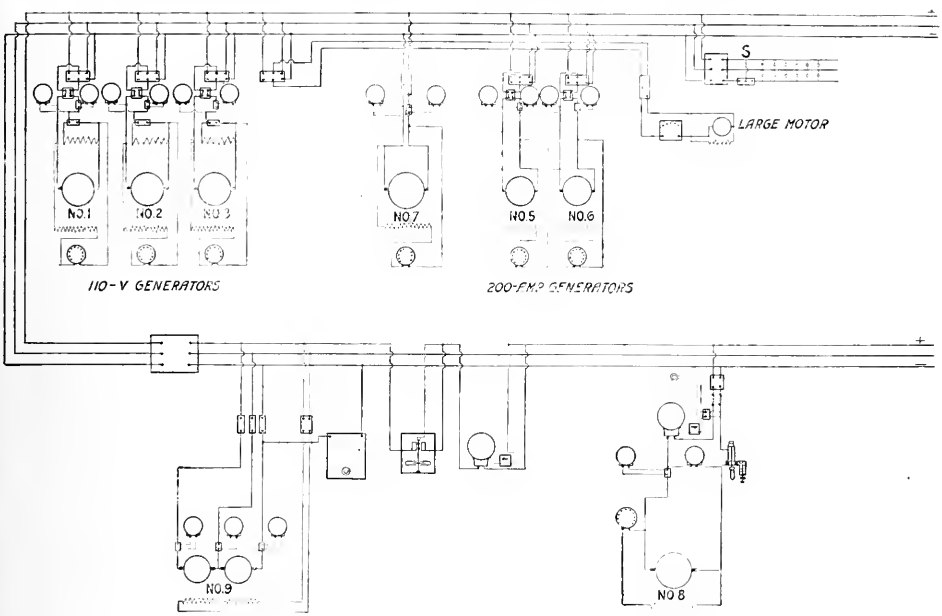


Fig. 2. Diagram of Generator Wiring

porary switchboard. It was at this time that the temporary balancer set described in POWER, July 14, 1914, was put in service.

This plan of operation continued for some time, though all the 220-volt generators were moved to the new power house. When at last the other 220-volt machines arrived and the new switchboard was set up, the 110-volt dynamos were taken out of service, the two 110-volt, 200-amp. machines being combined to make a balancer set.

In connection with generator No. 8 (Fig. 2) is shown the permanent plan of wiring the 220-volt generators, of which there are 10 at present. Each panel carries a wattmeter, an ammeter, a voltmeter, a pilot light, a circuit-breaker, a rheostat, and a switch with fuse blocks.

The unit system in this plant gives great flexibility and makes it possible to rush the testing of tractors during busy times. These tractors range from 30 to 80 hp. There is never any trouble regarding shift changes, for the care of the tractors requires but little time and all filling is done with hose connected to pipe lines. The power is cheaply developed, for the tractor motors use fuel at 4c. per gallon. Of course, the greatest advantage is the thorough testing of the tractors with little, if any, extra cost. All in all, the plant is very satisfactory and efficient, though the noise is not pleasing to the man who is accustomed to quiet-running Corliss engines.

Government Furnishes Cheap Electricity

By Herman B. Walker

SYNOPSIS—A hydro-electric plant which forms part of the Minidoka irrigation project in Idaho sells its surplus power to the community at such rates as to encourage the use of electricity for heating and various domestic purposes, a notable example being the high school at Rupert.

There is not more than one thousand population in each of the towns of Heyburn, Rupert and Burley, which are the post offices and marketing centers for the farmers on the Minidoka irrigation project, in the southern part of Idaho; but it is probable that few cities have adopted electricity for so many purposes. To irrigate this part of what used to be known as the Idaho Desert, the U. S. Reclamation Service built a dam 600 ft. long and 50 ft. high across the Snake River, forming an artificial lake covering 26 square miles, and at this dam installed a hydro-electric plant capable of producing 30,000 hp. The Government carries this power to the towns and farms scattered over the project, uses part to pump water to land too high to be irrigated by gravity, and sells electricity to farmers, settlers and distributing companies in the towns, at rates as low as half a cent per kilowatt-hour.

The lowest rates are made for power and for heating purposes. In the winter the power from the government plant is not needed for pumping water, and the low rates offered have resulted in many of the houses and business buildings being heated by electricity at a lower cost than they could be heated with coal, which in this section (Wyoming bituminous) is worth about $6.25 a ton.

Nearly every house and many of the barns on the Minidoka project are lighted by electricity, while the farmers' wives do their cooking on electric ranges, and the farmers run their pumps, grindstones, cream separators, churns and other farm machinery by electricity.

Last year the town of Rupert built a $50,000 high school, and after figuring on costs, left off the chimneys and put in an electric heating plant. This schoolhouse has probably the most modern equipment of any in the United States, if not in the world. When the janitor desires heat for the building he throws a switch instead of shoveling coal, and when he leaves for the night he throws out the switch instead of banking his fires. The building is a three-story brick structure, desigued to accommodate 600 children, and the electrical installation exceeds 435 kw. The heating plant has a connected capacity of about 400 kw. and consists of eleven units, which makes it possible to regulate the heat with ease. Each unit has a capacity of 36.5 kw., on 400 volts, and consists of a stack of grid resistances.

The air is drawn in through a two-way damper which permits it being taken from either inside or outdoors. A fan with a capacity of 20,000 cu.ft. per min., located beyond the heaters, forces the hot air into the plenum chamber, the floor of which is dropped a few inches below the rest of the basement and is kept flooded with water. The hot air is blown across the surface of this water before entering the flues leading to the various rooms. About forty gallons of water a day is evaporated and carried to the rooms with the hot air, thus keeping the atmosphere moist. Foul air is exhausted through ventilating shafts leading to the roof.

An hour or two before school opens in the morning, the janitor starts the fan, turns on as many units of the electric heaters as he thinks necessary, and turns the air damper to draw the air from inside the building into the heating chamber. When the temperature has reached about 70 F., he turns the damper to draw the air from outside. When the building is closed at night, the two-way dampers are turned to exclude the outside air, the heating units are all switched onto 220-volt transformer taps, the fan is shut down and the air is allowed to circulate by natural current during the night. This keeps the temperature high enough to make the warming-up process in the morning quick and easy. The heating installation is designed to heat 20,000 cu.ft. of air per min. from zero to 70 deg. F., and has worked satisfactorily.

It has cost somewhat more for current than it would have cost for coal to heat the school, but the school authorities are convinced that the saving in the cost of installation, fireman's wages and depreciation has more than made up the difference, and that the electric plant under the existing conditions is actually more economical in the long run than furnaces or boilers. Furthermore, there is the greater elasticity of operation and the ease of adjustment to meet varying weather conditions.

Power for this heating is supplied by the Government at a flat rate of $1 per kw. per month, based on the maximum demand for the month, with the stipulation that the maximum demand for the season must be paid for at least four months out of the year.

In addition to the electric heating, the school has a complete domestic-science department with an equipment of individual electric hot-plates for twenty pupils. There is also a large electric range for baking and for cooking the dishes supplied to the school cafeteria, where the pupils are supplied with hot meals at cost. An electric water still which not only furnishes distilled water for the school, but also supplies the local drug store, where the water is exchanged for the chemicals used in the school laboratory, is another unusual equipment. Water for the toilets, the shower baths in the gymnasium, dishwashing in the domestic-science room and for the laboratory, is heated by a 3-kw. circulating heater connected to a 250-gal. hot-water tank. The machinery in the manual-training room is operated from the 10-hp. variable-speed motor which drives the ventilating fan. A 450-watt stereopticon is a part of the school equipment.

On this project, in summer, the government power plant sends current to several points to pumping plants, and pumps water for irrigating approximately 50,000 acres of farms, mostly alfalfa fields, the average pumping lift being 66 feet.

The Government is required to allow a certain amount of water to pass through the dam at Minidoka, as there are interests further down the stream which have prior water rights. The water passed on for use below is dropped through 10-ft. penstocks and drives five main generating units of the vertical type, each of 2000-hp. rated capacity under a head of 46 ft., and two 180-hp. turbine-driven exciters. The power is transmitted at 33,000 volts over 40 miles of transmission lines to the pumping stations and transformer stations for town use. The average cost of generating electricity and delivering it at the pumping plants on the project, including 10 per cent. on the investment for depreciation and other items, has been about 0.6c. per kw.-hr. The cost of pumping water for irrigation has been about $1.40 per acre per season.

The rates charged to consumers on the project are:

FLAT-RATE LIGHTING

	Per Month
For 20 incandescent 15-watt lamps	$1 50
Per additional lamp	0 05
For 5 incandescent 15-60-watt lamps	1 50
Per additional lamp	0 25
Per light over 60 watts, for each 60 watts or fraction thereof	0 25
Per arc lamp, 700 watts, to 10 p.m.	2 50
Per arc lamp, 700 watts, all night	4 00

HEATING RATES

Per device, per 1,000 watts, winter	1 50
Per device, per 1,000 watts, summer	2 50

FLATIRON RATES

Per flatiron, 700 watts	0 50

METERED LIGHT AND APPLIANCE RATES PER KW.-HR.

First 25 kw.-hr. in month	0 07
For 25-50 kw.-hr. in month	0 06½
For 50-100 kw.-hr. in month	0 06
In excess of 100 kw.-hr. in month	0 05½

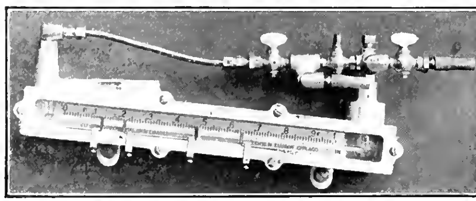
POWER RATES PER KW.-HR

First 100 kw.-hr. in month	0 05
For 100-200 kw.-hr. in month	0 04
For 200-500 kw.-hr. in month	0 03
For 500-1000 kw.-hr. in month	0 015
For 1000-2000 kw.-hr. in month	0 008
For 2000-5000 kw.-hr. in month	0 007
For 5000-50,000 kw.-hr. in month	0 0063
For 50,000-75,000 kw.-hr. in month	0 0060
For 75,000-100,000 kw.-hr. in month	0 0057
In excess 100,000 kw.-hr. in month	0.0055

New Ellison Combination Differential Draft Gage

The accompanying illustration shows the latest addition to the long list of Ellison gages. By the application of a simple system of cross-connecting, the cover-type differential draft gage, the flue draft, the furnace draft or the differential between the flue and the furnace, indicating the variations of the air supply, can all be indicated on a simple gage, over the full length of the scale. The fittings are of brass and the tubing of copper. Each connection is furnished with a piece of rubber tubing for a ⅛-in. pipe, serving as a flexible joint for relieving the gage from pipe strains and from shocks when the pipe lines are accidentally struck with the fire tools. By means of the elbows with locknuts, the combination can be turned to the right, left, or up.

The tube at the right connects with the flue piping on the boiler side of the damper, or with the last pass, and the connection at the left with the furnace piping in the usual manner. To indicate the flue draft the flue cock is opened and the other two are closed, the cock



NEW ELLISON COMBINATION DIFFERENTIAL DRAFT GAGE

at the left being pinned at quarter turn and so vented that when closed, the zero end of the gage is open to the atmosphere.

To indicate the furnace draft the outside cocks are closed and the middle cock opened, the economical range of furnace draft being maintained between the pair of pointers at the left, which are set as directed on the cover-type differential draft gage.

To give a continuous indication of the variations in the air supply, for which the gage is chiefly intended, the outside cocks are opened and the middle one closed. The reading is maintained between the second pair of pointers, which are set to check with the furnace pointers, the right being red, beyond which the liquid should not pass except under excessive overloads. The object of the pointers is to maintain the liquid as nearly as possible to zero and still carry the load without producing CO.

To establish the liquid at zero all cocks are closed and the plug over the chamber unscrewed until the vent in the threaded portion stands out of the fitting.

Manifolds can be furnished in place of the flue nipple, for connection with various flue-gas passages, while a pressure nipple can be furnished with an ashpit connection, for indicating the blast or the differential between the ashpit and the furnace. The scale of the gage is divided into hundredths of an inch, and the movement of the fluid is magnified ten or fifteen times. The inventor and maker of the gage is Lewis M. Ellison, 6238 Princeton Ave., Chicago, Ill.

Why Direct-Current Motors Fail to Start—II

By F. A. Annett

SYNOPSIS—The effects of open field circuits and how to locate the trouble; also the use of a water rheostat as a substitute for a starting box.

The causes of direct-current motors failing to start as described in Part 1 (Feb. 9, 1915) will not affect other parts of the apparatus, such as causing the fuses to blow, the starting box or other parts of the machine to heat, etc.

A break in the field circuit will produce several different effects, depending upon the winding, the setting of the brushes, and whether or not the machine is loaded. If series-wound it will not start, for the field winding is part of the armature circuit. If shunt-wound and the brushes are set at the neutral position the motor will not start, but shifting the brushes off neutral will cause rotation in the direction in which the brushes are shifted, provided the machine is not loaded. A compound-wound machine with the shunt field winding open will usually start whether loaded or not, but unless heavily loaded it will usually race. If the series field winding is open it will have the same effect as in a series machine.

In the shunt field circuit a break may occur anywhere between the first contact point on the starting resistance around to where the field coils and armature leads connect to the line wire, as indicated by the arrowheads in Fig. 1. As the no-voltage release coil on the starting box is located in an unprotected place, it is usually one of the chief sources of open circuit in the shunt field circuit; therefore, it should be given first consideration.

Assume a condition as illustrated in Fig. 2 where the no-voltage release coil is open at *X*. This interrupts the shunt field circuit, but leaves the armature circuit complete, and may cause any one of the effects enumerated. Where an attempt is made to start a shunt- or compound-wound motor with the shunt field circuit open, if it starts it will run at high speed, the starting resistance will become very hot, and if an attempt is made to cut out the resistance the fuses will blow and the machine will spark badly at the brushes and commutator.

A simple test for this defect is to disconnect the armature lead *A* on the starting box, close the switch, and bring the arm upon the first contact. If the field circuit is closed, a spark will occur when the arm is allowed to drop back to the off position; if open, no spark will occur. To locate the defect in the starting box, disconnect the armature and field connections, close the switch and bring the arm upon the first contact; then test with a lamp, as at *L* and *L'*, Fig. 3. When the lamp is connected to terminal *A* it will light, for the circuit is completed through the starting resistance, as indicated. When connected to terminal *F* it will not light, for the circuit is open at *X*; the coil may then be tested by connecting the lamp first to one and then to the other terminal, as indicated at *a* and *b*. If the lamp lights at *a* and not at *b*, as in this case, it indicates that the circuit is open between the two terminals of the coil, which may be removed and again tested to make sure that the trouble has been properly diagnosed.

If the defect cannot be located and repaired and the coil has to be rewound, it does not necessarily mean that the motor has to be shut down until the repairs have been made. This difficulty can be temporarily overcome by connecting terminals *a* and *b* with a piece of wire. However, it will now be necessary to tie the starting arm or remove the spring, to keep it in the running position. For a more detailed explanation on open circuits in field coils see Power, Aug. 4, 1914.

Sometimes it is necessary that the starting box be taken to the shop for repairs, or it may have been completely burned out and a new one is required. In such cases, if a duplicate starter is not at hand the motor must remain shut down unless some substitute is provided for starting. One of the most convenient substitutes is a water rheostat. This is made up of a common 10- or 12-quart pail, a wood or pulp pail being preferable, as there is less danger of a short-circuit. Two electrodes must be provided; one a flat plate which rests on the bottom of the rheostat and connects to one side of the line, the other any piece of metal that is at hand and connects to the armature. The pail is filled with water containing a handful of common salt to increase its conductivity. This size of rheostat will be sufficient for starting a 25- or 30-hp. 230-volt motor under full load, or a 100- to 150-hp. motor under light load.

Fig. 4 illustrates the proper method of connecting the rheostat in circuit for starting a shunt motor. In making the connection care should be taken to get the rheostat in series with the armature only and the field connected directly to the line, as shown. If the field is connected to the armature wire leading to the movable element of the rheostat, the motor will have a very weak torque at starting. To start a motor with a water rheostat proceed as follows:

See that electrode *a*, Fig. 4, is removed from the rheostat; then close the line switch and lower *a* slowly into the pail. As soon as it is immersed in the liquid the machine should start. Continue to lower *a* gradually until it comes in contact with electrode *b* at the bottom of the pail. To insure good contact while the machine is running, a single-pole switch *S* may be used to short-circuit the rheostat after the machine has been brought up to speed. This short-circuiting switch must be open when the line switch is closed to start the motor, or the fuses will blow. If difficulty is experienced in getting the motor to start properly through the rheostat, more salt may be added.

The proper method of connecting a compound motor is shown in Fig. 5, which is practically the same as for a shunt machine. If a metal pail is used electrode *b* may be dispensed with and the line wire connected directly to the pail.

A short-circuit in one or more of the field coils of a multipole machine will prevent it from attaining normal speed. However, it will start with a good torque, but as the speed increases sparking will occur at the commutator and brushes and excessive current will be drawn from the line; and by the time three or four points of the starting resistance are cut out, conditions will become so bad as to necessitate shutting the machine down, or the fuses will blow.

A ground in two or more field coils if the system is insulated, or a ground in one field coil where the frame of the machine and one side of the line are grounded, will have practically the same effect as a short-circuit in one of the field coils. A method of locating these defects was described in POWER, Sept. 1, 1914.

Another defect which will prevent a motor from attaining full speed is a short-circuit of a group of armature coils. This will cause the machine to start with a jerky effort, and before the armature has accelerated very much it will act as though heavily overloaded; and if an attempt is made to cut out the starting resistance the fuses will blow. The method of locating this defect was treated in POWER, Nov. 17, 1914.

Two grounds in the armature winding will have practically the same effect as short-circuiting a group of coils. One ground in the winding, combined with a ground on the external circuit, will cause the fuses to blow.

If the brushes are shifted so that they are equidistant between the neutral points, the machine will not start, but will draw an excessive current from the line and blow the fuses if the starting resistance is cut out.

To set the brushes on the neutral point when the machine is standing still, follow out the leads of the armature coils located between the polepieces and set the brushes on the segments to which these leads connect. The proper position for the brushes is usually opposite the center of the polepieces or opposite the center of the space between them. In most modern machines it is opposite the center of the polepieces.

If the machine is compound-wound a short-circuit between the series and shunt field coils will have about the same effect as a short-circuit in the field coils of a shunt machine. This condition is illustrated in Fig. 6, where a short-circuit is indicated at X between the shunt and series field coils on polepiece B. On account of the low resistance of the series field winding, the current through the shunt field coils will take the path indicated by the arrowheads, short-circuiting the shunt field coils on polepieces C and D and part of the coil on B.

A quick test can be made for this defect, as shown in Fig. 7. Open the connection between the series and shunt fields at the motor and the armature connection A at the

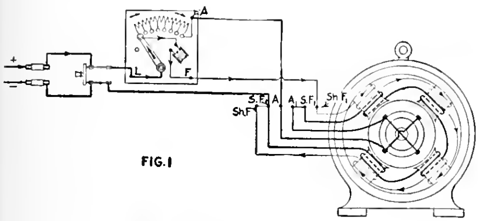


FIG. 1

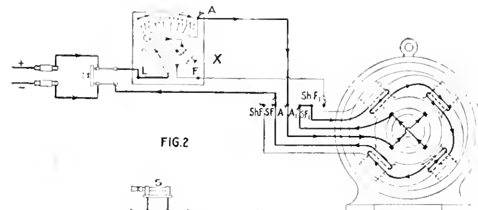


FIG. 2

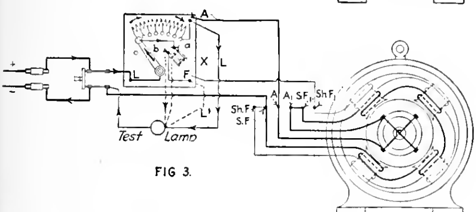


FIG. 3

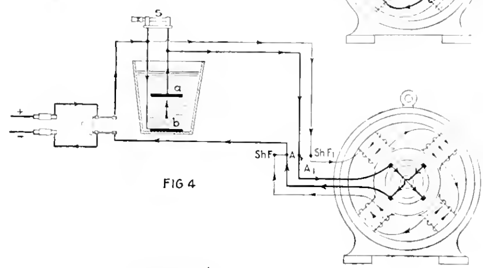


FIG. 4

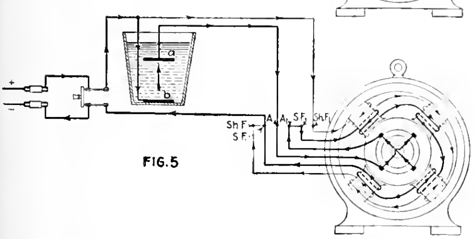


FIG. 5

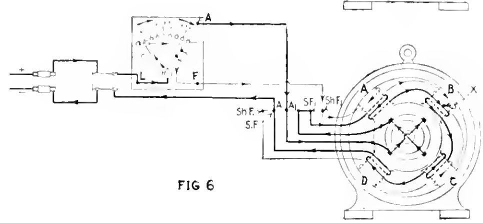


FIG. 6

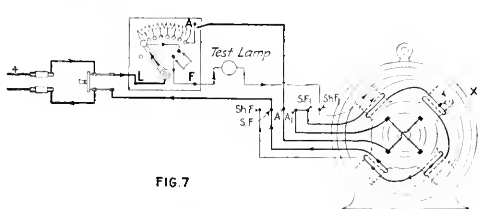


FIG. 7

TESTING FOR BREAK IN CIRCUIT AND STARTING MOTOR BY MEANS OF WATER RHEOSTAT starting box. Connect a test lamp in the shunt field circuit as indicated, close the switch and bring the starting-box arm upon the first contact. If the lamp lights it denotes a short-circuit between the series and shunt fields, as shown by the arrowheads. The defective coil may be located by opening the connections between the field poles and then testing between the series and shunt coils on each polepiece with a lamp or voltmeter.

In locating trouble never forget to test the machine and the controlling device for grounds, as a combination of grounds on a motor and controller sometimes produces some very puzzling and, at first thought, unaccountable effects which are easily explained after the trouble has been located.

Boilers for Isolated Plants

By Charles L. Hubbard

SYNOPSIS—A brief treatise on the selection of boilers for isolated plants, together with the more important matters to be considered in connection with boiler design and operation.

Selection of a Boiler

Among the governing factors in the selection of a boiler are the pressure to be carried, size and number of units, available space, and cost. To these may be added details of construction, relating especially to accessibility for inspection, cleaning and repairs.

When the boilers are furnished by builders of established reputation, it is not usually necessary for the engineer to prepare detailed drawings and specifications. General requirements as to pressure, amount of heating and grate surface, and type of furnace and setting are furnished the builder, from which he, in turn, prepares specifications for the approval of the engineer and which are submitted with his bid. This applies especially to water-tube and patented boilers, of which there is a great variety. In the case of fire-tube boilers of the horizontal type, the engineer often furnishes specifications, particularly where any departure from standard construction is required.

The boilers most frequently used in isolated plants are the horizontal return-fire-tube and the standard makes of water-tube boilers. Vertical fire-tube, locomotive and marine boilers are also used in special cases. In the matter of fuel consumption for a given capacity there is little choice in the different types of equal grade, hence adaptability and cost are the governing features in making a selection.

Return-tubular boilers are rarely used for pressures over 150 lb. or for sizes much above 125 hp., because of the thickness of plate required, which in general should not exceed ½ or ⅝ in., owing to its exposure to the hottest part of the fire. Within these limits they are an efficient type and are especially adapted to low basements. The first cost of a return-tubular boiler is somewhat less than a water-tube boiler, which is sometimes a deciding factor.

For larger units and higher pressures some form of water-tube boiler is usually selected. Boilers of this type are also frequently employed in small- and medium-sized plants on account of greater safety, and special designs are constructed for locations where headroom is limited.

Boiler Capacity

The capacity of a boiler is based upon the weight of steam which it will furnish in a given time under specified conditions; the standard of measurement being the weight of dry steam evaporated per hour from and at 212 deg. The performance of a boiler operating under other conditions may be reduced to this standard by the use of a table of "Factors of Evaporation," which may be found in most handbooks. Table 1 gives the factors of evaporation over a small range and in a condensed form merely for present purposes.

TABLE 1. FACTORS OF EVAPORATION

Temperature of Feed Water, Deg. F.	Gage Pressure in Pounds per Square Inch								
	100	110	120	130	140	150	160	170	180
50	1.208	1.210	1.212	1.214	1.215	1.217	1.218	1.220	1.221
60	1.198	1.200	1.202	1.203	1.205	1.207	1.208	1.210	1.211
70	1.187	1.189	1.191	1.193	1.194	1.196	1.197	1.199	1.200
80	1.177	1.179	1.181	1.183	1.184	1.186	1.187	1.189	1.190
90	1.167	1.169	1.170	1.172	1.174	1.176	1.177	1.179	1.180
100	1.156	1.158	1.160	1.162	1.164	1.165	1.167	1.168	1.170

Example—A boiler supplied with feed water at a temperature of 70 deg. generates 4000 lb. of dry, saturated steam per hour at a pressure of 180 lb. gage. What is its equivalent evaporation from and at 212 deg.?

The factor for the above conditions from Table 1 is 1.2, hence the equivalent evaporation under standard conditions is $4000 \times 1.2 = 4800$ lb. of steam per hour.

The heat required to evaporate one pound of water from a temperature of 212 deg. into steam at atmospheric pressure is 970.4 B.t.u.

One boiler horsepower represents the capacity to evaporate 34.5 lb. of water per hour from and at 212 deg., which process requires $970.4 \times 34.5 = 33{,}479$ B.t.u. In practical work this is commonly taken as 33,000, which gives results on the side of safety.

What is commonly known as heating surface includes all the plates and tubes exposed to hot gases on one side and water on the other. Surface coming above the water line and exposed to hot gases on one side and steam on the other is called superheating surface.

The effectiveness of the various heating surfaces depends upon their location and character, but in all computations relating to boiler capacity, it is customary to assume a uniform value for the entire heating surface which shall represent a fair average under ordinary working conditions.

For power work an evaporation of 3 to 3.5 lb. of water per sq.ft. of heating surface per hour may be taken, which calls for $\frac{34.5}{3} = 11.5$ sq.ft. per hp. in the first case and $\frac{34.5}{3.5} = 9.9$ sq.ft. in the second.

Builders usually rate their boilers on a basis of 10 sq.ft. of heating surface per hp. for water-tube boilers and 12 sq.ft. for return-tubular boilers, but as no uniform rule is followed in this respect, the engineer should always specify the amount of heating surface required rather than the horsepower. Some engineers call for a guaranteed evaporation under standard conditions as to feed-water temperature, steam pressure and coal consumption.

In the case of return-tubular boilers, it is well to state the diameter and number of tubes for a given diameter of shell, as the efficiency is lowered by crowding them too closely together. Table 2 gives tube data as recommended by the Hartford Steam Boiler Inspection & Insurance Co.

TABLE 2. TUBE DATA

Diameter of Shell, In.	Diameter of Tubes, In.	Number of Tubes
48	3	44
54	3	54
54	3½	46
60	3	72
60	3½	64
66	3	90
66	3½	78
66	4	62
72	3	114
72	3½	98
72	4	72

Efficiency

The efficiency of a boiler plant is made up of the combined efficiencies of the furnace and boiler and is expressed by the ratio:

$$\frac{\textit{heat absorbed by water in boiler per lb. of coal, as fired}}{\textit{calorific value of one lb. of coal, as fired}}$$

When oil fuel is used or mechanical appliances are provided for feeding the coal or creating a draft, the heat required per pound of fuel for this purpose must be deducted from that delivered by the boiler in the form of steam for useful purposes in order to obtain the net efficiency. The heat absorbed by the water in the boiler per pound of coal equals

$$\frac{970.4 \times W \times q \times f}{w}$$

in which

W = Apparent weight of water evaporated, in pounds per hour;

q = Quality of the steam;

f = Factor of evaporation for the conditions of feed temperature and steam pressure during the test;

w = Weight of coal burned, in pounds per hour.

The calorific value of coal varies with the kind and the locality from which it comes, and should be determined in each particular case for accurate results. For approximate work, the following values may be used:

TABLE 3. CALORIFIC VALUE OF AMERICAN COALS.

Kind of Coal	Calorific Value in B.T.U. per Pound
Anthracite.........	13,200
Semi-anthracite.......	13,800
Semi-bituminous.....	14,700
Eastern bituminous......	13,600
Western bituminous.......	12,300

In general, the efficiency will run from 50 to 70 per cent., averaging about 60 per cent. in well designed and carefully operated isolated plants of good size. This applies to boilers working under normal conditions. When forced beyond the capacity for which they are designed, the efficiency falls off somewhat, although not so much as was formerly supposed.

Boiler Performance

This relates to the various results obtained in the practical operation of steam boilers, such as rates of combustion and evaporation, coal per horsepower-hour, etc.

The weight of coal burned per square foot of grate per hour depends principally upon the kind of fuel, the type of furnace and the strength of draft. Table 4 gives about the average for different grades of coal burned under natural draft. These figures, however, may vary 2 or 3 lb. either way, according to local conditions.

TABLE 4. RATES OF COMBUSTION WITH NATURAL DRAFT

Kind of Coal	Pounds Burned per Sq.Ft. of Grate per Hour
Anthracite buckwheat No. 1. .	9–12
Anthracite pea....	12–15
Anthracite nut...	14–18
Semi-anthracite, screenings..	14–18
Semi-anthracite, run of mine... ..	18–22
Semi-bituminous, screenings... .	18–24
Semi-bituminous, run of mine.....	18–24
Bituminous, slack. .	18–24
Bituminous, screenings.....	20–26
Bituminous, run of mine..	20–28

With mechanical draft the rate of combustion may be greatly increased if desired, but is not usually carried much over 30 lb. in stationary plants of medium size. With certain types of stokers, however, the best results are obtained with small grate surfaces and high rates of combustion, but for average practice with hand-fired furnaces, the figures given should be generally followed.

The rate of evaporation depends partly upon the grade of fuel and partly upon the boiler and furnace efficiencies, which in turn are influenced by the character and arrangement of the heating surface and its relation to the grate area. Table 5 gives the pounds of steam evaporated per pound of coal for different calorific values and efficiencies within the usual range in isolated plants.

TABLE 5. POUNDS OF STEAM FROM AND AT 212 DEG. PER POUND OF COAL

Combined Efficiency of Boiler and Furnace	Calorific Value of Coal in B.T.U. per Pound 12,000	13,000	14,000	15,000
50 per cent	6.2	6.7	7.2	7.7
60 per ceot...	7.4	8.0	8.6	9.3
70 per cent..	8.6	9.4	10.1	11.8

The pounds of coal per horsepower-hour is found by dividing 34.5 by the rate of evaporation obtained in any given case. Table 6 has been prepared for the same conditions of boiler efficiency and calorific value of fuel as Table 5 and gives the pounds of coal required per boiler horsepower per hour.

TABLE 6. COAL CONSUMPTION PER BOILER HORSEPOWER-HOUR

Combined Efficiencies of Boiler and Furnace	Pounds of Coal per Boiler Horsepower per Hour Calorific Value of Coal in B.T.U. per Pound 12,000	13,000	14,000	15,000
50 per cent..	5 6	5 2	4.8	4.5
60 per cent.	4 7	4.3	4.0	3.7
70 per cent	4 0	3.7	3.4	3.2

Boiler Capacity for Power—All power requirements should be reduced to indicated horsepower. This, multiplied by the water rate of the engine, reduced to an equivalent evaporation from and at 212 deg. and divided by 34.5, will give the boiler horsepower required. Expressed as a formula, this becomes

$$b.hp. = \frac{i.hp. \times W.R. \times f}{34.5}$$

in which

$b.hp.$ = Boiler horsepower required;

$i.hp.$ = Indicated horsepower to be supplied;

$W.R.$ = Water rate of the engine under given conditions of feed-water temperature and steam pressure;

f = Factor of evaporation for given conditions.

Example—What boiler capacity will be necessary to supply power for a factory requiring 500 i.hp. at the engine? Power is to be furnished by a low-speed engine using 20 lb. of steam per indicated horsepower per hour. The average feed-water temperature is 60 deg. and the steam pressure 100 lb. gage. In this case

$i.hp. = 500;$

$W.R. = 20;$

$f = 1.198;$

which, substituted in the formula, calls for

$$\frac{500 \times 20 \times 1.198}{34.5} = 347 \textit{ boiler horsepower}$$

This gives simply the boiler power for supplying the engine. If steam is required for other purposes, such as the driving of pumps, heating, ventilating, etc., the capacity should be increased accordingly.

Boiler Capacity for Heating, Ventilation, etc.—The general method employed in this case is the same as above described. All heating requirements are reduced to pounds of steam per hour and the result divided by 34.5 to find the boiler horsepower.

Paint for Engineering Purposes

By E. N. Percy

The writer had occasion recently to investigate the principles of paint making, because his employers were not satisfied with the results in the upkeep of painted surfaces in their various power plants. The results of these inquiries may be of interest to practical men.

There are many ways of making paints, but only a few for good paint. There are also many ways of using paint, but only a few for getting good results. Nothing goes further toward improving the appearance of a power plant than the judicious use of paint and varnish, and a man need not be a highly trained painter to get fairly good results if the underlying principles are known.

Protective coats may be divid l into three general classes, viz., paints, varnishes and dips.

Paints consist of a body, which is to be the protective coat, and the solvent in which the body is dissolved. The solvent in some paints evaporates and leaves the body; in others, it oxidizes and hardens with the body. In addition to these two ingredients, it is customary to add coloring matter, unless the body is already of the color required.

Varnishes consist of a body and solvent, and are used to give a glazed finish, impervious to the elements. Varnishes are sometimes used as fillers, prior to the application of paint; again, they are used as a protection to the paint, particularly if the paint is of an expensive and highly ornamental character. Dirt may be washed from varnish, whereas it sticks more or less to paint. Varnishes may be colorless and transparent, or may be stained to any desired color.

Dips are protective coatings into which articles may be dipped, after which the coating is hardened to the desired texture by cooling, baking in an oven or by further dipping in another compound. Such coatings include lacquer for brass, cast iron, copper or wooden pipes, etc.

Well known combinations for paint are white lead and linseed oil and coloring matter, kerosene or gasoline and lampblack, or linseed oil and lampblack.

Without doubt, there is no paint known that equals pure white lead and boiled linseed oil for general protection. For white coats, it may be used without other ingredients; for any other color, the pigment may be procured at any paint shop. It is almost impossible to get contract work done with pure white lead and pure boiled linseed oil; but this is the only way to have high-grade work done. The writer has had to go to the greatest extremes, with inspectors, chemical tests, etc., in order to compel contractors to use pure white lead and linseed oil, because of their high cost. The usual substitute is zinc, and even this is often mixed with chalk or lime.

Red lead is an excellent protection for steel work; it does not show the dirt and is much cheaper than white lead.

Cheaper paints are made with asphaltic and tar products dissolved in gasoline, distillate, benzine, benzol, linseed oil or kerosene.

Varnishes consist mostly of rosins or tree gums dissolved in turpentine, alcohol, gasoline or boiled linseed oil. The solvent then evaporates (known in this case as a spirit varnish) or hardens by oxidation (known as an oil varnish). Among the cheaper varnishes are shellac, inside finish, etc. The more expensive varnishes are those intended to endure stress of weather, like automobile finish, etc. The pyroxylin or celluloid varnishes are made from cellulose. The celluloid is dissolved in wood alcohol or in amyl acetate (banana oil), and may then be mixed with coloring matter or heavier bodies, such as a solution of asphaltum in gasoline. It then imparts a high, glossy finish. It has been found, however, that the pyroxylin varnishes do not withstand the elements and are therefore suitable for inside work only.

The pyroxylin varnishes are suitable for finishing and protecting metal surfaces, provided the metal is not highly heated. They also prevent oxidation, and preserve highly polished surfaces. A fine grade of pyroxylin varnish may be made by dissolving moving-picture films in wood alcohol. The film can be secured from any large film exchange, as they always have quantities of worn-out films on hand, which are merely burned up as so much waste. A thousand feet of film, unwound and stuffed into a ten-gallon drum, may be covered with wood alcohol and the drum closed. It should be left for a week, and the drum turned over every day. Then the liquid may be drawn off and will be found to be a good grade of varnish. The drum may be filled again, as the film will last for months. The emulsion settles to the bottom as a sort of mud, and one must be careful to decant the liquid so as to leave the settlings in the barrel.

The varnish is ideal for glossy, metallic surfaces, particularly those that tarnish, such as brasswork, metallic paint, copper pipes, etc.

The metallic paints consist merely of finely divided metal mixed with some oil or body which will cement them together and to the surface, and then the liquid portion will either oxidize or evaporate. The metals consist of gold, silver, bronze, brass, copper, aluminum, iron, and sometimes zinc. These paints must not be confused with ordinary paints, which are compounds, such as lead oxide (white lead; red lead is another lead oxide), white zinc (zinc oxide) or copper ship paint, which is copper sulphate as a rule. The finely divided metals which go to make metallic paints are secured partly by grinding, partly by electrolysis, and others are byproducts of some other process or industry. The cheaper gilt paints are, of course, imitations, but the more expensive ones are pure gold leaf. The leaf is so very thin as to be reasonably cheap, since it takes thousands of them to make a pile one inch high.

Dips are very important to the engineer, because they are the principal method of protecting pipe, brasswork, etc. Most dips are applied hot. Pipe dips are mostly black, and must withstand the action of water, air, weather, soil and heat. The coating must be hard and glossy, but must not chip or crack, nor run or flow when subjected to moderate heat. Such results may be obtained with certain grades of coal-tar products, also asphaltum. The coal-tar products are affected more easily by heat than the asphaltum, but it is important to get the proper grade of asphaltum. Probably the most satisfactory is a medium grade of air-blown stock of such hardness as will be determined after a few experiments. This asphalt should be dissolved in boiled linseed oil in a vat over a fire until the mixture contains two parts of molten asphaltum to one of linseed oil. Care must be taken not to get the mixture too hot, as the asphaltum will be brittle if burned. A fair dip is obtained with only 10 per cent. of linseed oil, but the coating is more likely to chip.

Lacquer for brass work is made in numerous ways, but a fair coating can be obtained by dipping in a hot mixture of pure linseed oil and pure white rosin melted together. Care must be taken that the bath does not take fire.

The Purchase of Coal

By Morgan B. Smith

SYNOPSIS—Some factors which ought to be considered by the consumer when purchasing coal.

In connection with the purchase of coal two questions arise, both of which may seem odd but which nevertheless bring forward intensely practical answers. The first is, *why* does the consumer purchase coal? and the second, *how* does the consumer purchase coal? The first question may be answered by the simple statement that the coal is bought for heating purposes. This answer is ready and straight to the point; but how about the second question—can this be answered as readily as the first? Unless the purchaser has been through the mill thoroughly he will state that he buys coal from his dealer at so much per ton, plus freight charges, and then puts it in storage in field or bunkers, or perhaps burns it at once in the furnaces.

It is worth while to consider the answer to the second question. There is more involved in the purchase than mere tonnage. The purchaser himself admits that it is heating value which he desires. Therefore, he should look for heating value per ton of coal bought and also for nonheating properties in the coal.

Stop to consider, then, some of the factors to which the consumer ought to give attention when purchasing coal for his plant. In the first place, he is forced by current practice to buy "tons of coal," regardless of the true value to him, unless he is in a position to insist upon "heating value per ton of coal."

What does this mean to the consumer? It means that he is paying for mere weight of coal, for freight on mere tons, for handling at the plant of mere tons, for crushing mere weight, for storage of weight only, for burning weight only and for handling ashes—all based upon mere avoirdupois rather than upon heat value. Is this common sense or good judgment? Hardly.

Supposing that he is in a position to insist upon heating value in every ton of coal which he purchases, and to make his insistence strong by means of the proper tests on all coal received at the plant. What then? The purchase of coal then becomes a matter, not of mere tons, but of heat units per ton or per pound, a measure of the coal's real value.

When the purchaser has reached this position regarding coal, he can then go ahead and by comparative tests select the coal best suited to his plant equipment. That coal which is by its characteristics best adapted to the conditions of the plant and the load is the highest grade usable, regardless of cost.

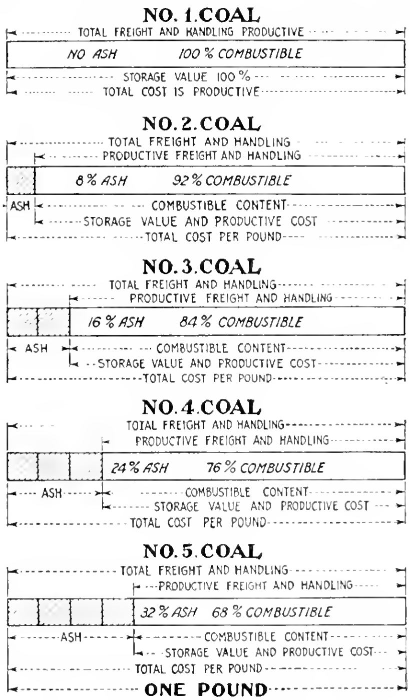
It is customary to state the heat value of coal in terms of heat units per unit of weight, generally stated as British thermal units per pound (B.t.u. per lb.) based on the sample dried at 105 deg. C. for one hour. Unless the exact characteristics of the coal are known, a pound of it may have diverse meanings to the buyer. To make this clear, the accompanying diagram has been made to illustrate graphically how "one pound of coal" may have great significance when all costs and efficiency in the plant are considered.

Assume the initial cost at the mines to be the same for each of the five coals shown. How much of the total cost is productive? Only that portion represented by the heat content of the coal purchased. How much of the total cost is loss? The difference between the total cost and the productive cost. The content of fixed carbon and volatile matter is a measure of the productive cost, whereas the ash content is the nonproductive cost. Which is wanted, heat value or ash?

No. 1 coal is a purely hypothetical coal, not found in nature, but shown here for the sake of comparison only. Coals Nos. 2 to 5 are representative of coals on the market and show a common range of characteristics. Which of these coals will give the best results in cost and efficiency in the plant, from mines to bunkers and ultimately to the ash dump? Does storage value mean anything when, through strikes at the mines or stoppage of transportation by floods, the plant is threatened with a shutdown? If so, which of the four coals would it be preferable to have the bunkers or field filled with in such an emergency?

The cost does not stop with the original price per ton plus freight, for handling, crushing, storing charges on the coal and also handling of the resultant ash must still be covered. It is generally conceded that coal high in ash and sulphur is harder on all handling apparatus than a coal of lower ash and sulphur content. The costs for upkeep of apparatus will then be in proportion to the wear and tear upon such equipment. In the furnaces evolution of heat is the desired output and will vary directly with the heat content of the coal used. The higher the heat value, the greater the amount of heat liberated, all other conditions being similar. Finally there are the charges for handling the ashes produced. These costs vary directly with the ash content of the original fuel burned.

In general, it may be said that the higher the quality of coal which the plant will handle economically, the lower will be the costs and the greater the efficiency of the plant. It is not necessary that the dealer be held to a strict specification of properties of the coal purchased, although it is wise for the purchaser to acquaint himself with such characteristics and for his own satisfaction



Diverse Meanings of One Pound of Coal to Consumer

formulate a specified analysis. He will find that daily tests on all coal received at the plant, or possibly weekly averages, will afford him valuable data, and if he sends copies of all such tests to his dealer, he will find himself possessed of powerful ammunition with which to convince the dealer that it is to his interests, as well as those of the purchaser, to furnish the coal desired. Such an arrangement tends toward mutual satisfaction since it places both parties to the contract on an equitable footing.

The tests which should be made regularly are those to determine the heat value per pound of coal as fired, ash content as fired and percentage of sulphur. These tests give all the required data. Other tests may be made, often of value to the consumer, such as the determination of fixed carbon and volatile matter. Moisture must always be determined in order to calculate the coal to the condition "as fired" or net weight of coal burned. These are simple tests, and the apparatus is not expensive when the results are considered. By all means adopt the oxygen-bomb type of calorimeter for determining the heat value of coal. Other calorimeters are at best only approximate in their results, although cheaper in first cost.

The purpose has been to point out the real meaning of "coal" to the purchaser and consumer and to emphasize the fact that only by knowing the fuel can the user reach that degree of standardization in his fuel purchase and combustion which has been the real factor in producing the high efficiency of the modern power plant. It is a fact that uniform fuel means uniform and economical operation in the plant.

Smoke Agitation in Slowville

Deer power

i found wun uv yer papers The uther da and i saw whare a Hull lot uv ingineers had Rote leters ter yu, so i thot ide skrible this wun ter let mi brother ingineers no bout the perfeshun doun our Wa. ive bin folerin ingineerin fer nigh Onto 22 yere (not countin the tim i hawled gravl fer pete swint).

ime runin a engin 6 foot by 11 foot not countin the brase i had put agin the silinder hed what got kraked wun da whil i wuz Out lookin at The cirkus go bi. i haint ever mesured the boilr Yit but wil az sune az i kin boro a tape Lin.

mi bos cum down the uther da an toled me he ud jest got a Notis frum the antysmok kumitty (witch i gess is sumthin lik the temprunce unyon) to kwit makin so mutch smok Doun at his spok factry. The bos sed he gesst he wud hav to git a nu ortymobil stokr lik the Notis sed.

Now that jes maid me rile Up, caus i lai clame tu bein the best stokr fierman Herebouts. i haint extry big, but ime stoutern a hors. Why i shuveld 400 lb. uv bug dust in mi furnis wun da in 3 minits by Bill jones watch. i dident luk ter se if It maid eny smok, but i dont bleve it did, fer twuz on a munda i maid the rekard an the widder Simpling, just acrost the wa allers Washes on munda and she wud ov razed cane if eny sut got on her close.

The bos kin tri sum wun in mi plase if he wants ter, butt he wil be Sory an wish i wuz back cuz i kno rite whare ter hit the guvnr ter make er stop evry tim the ingin runs Off.

A feller cum in next da and sed he wuz the smok inspektr an wuz backd up by the mayer. the mayer haint no frend uv min and i wudent Vot fer him las spring cuz wen he wuz tax inquizitr he stuk me 2$ fer a chocaletculerd dog thet i hed trid ter driv Off fer a yere.

The inspektr feller sed he gest if mi boilr hed mor draft it wudent mak so mutch smoke. i jest up an toled him he didnt no his biznes cuz i hed often notisd wen smokin mi pipe thet the Harder i suckd the more smok i maid, an it stans ter reson a boilr Wil du the saim. he tride ter tel me ther wuz a patent furnis what burnd the smok an i toled him ter quit foolin cuz yu kant burn nothin what yu kant git hold uv. He went out alukin sad liek.

i ges tha ar tryin ter pla a jok on me lik tha did ter the last pol Rasin wen Old judkins sent me bout tu miels ter boro old Skinners ski huks. If eny smok feller cums roun tryin ter bothr yu, jest thro him out.

yurs trully Hi Swope

Editorials

Good Specifications

A specification or written contract should be a binding agreement that will hold good in law, and should also define or describe so clearly that no doubts can arise, when examined in detail, as to the meaning, scope and intention of the agreement. Simple, direct and comprehensive language alone will fulfill these needs. No matter how complex the idea, some way of expressing the meaning that will be clear to all parties is always to be found. Yet it is the rule, rather than the exception, on contract jobs for owners, engineers, inspectors, contractors and mechanics to be hindered one or more times by a dispute over the interpretation of some clause of the specification.

At such times it seems as if the ideal contract will never be written. Each of the interested parties is able to show good reasons for his contradictory interpretation of the meaning. The owner justifies his effort to get the best class of service and material for the least possible expenditure, and the contractor, on his side, strives to make the contract call for the least material and labor. These opposing interests of owner and contractor are the reason for the binding character of the agreement, and the frequent ambiguity of meaning may in many cases be traced to over-anxiety on the part of the writer to produce a document binding in law.

At the same time these opposing interests call no less for clear unambiguous specifications than for legal safeguards for the protection and control of both parties. Probably the best way to obtain such specifications is to have them written by some disinterested third party who is thoroughly familiar with the work to be done, the legal demands, and the necessity for perfect clearness. Another method of obtaining clear specifications and one which has been receiving considerable attention is the use of a uniform standard specification. Where applicable, this method appears to be best, the standard form being adapted from time to time to agree with an ever widening experience.

An Engineer Needs Judgment

It is the engineer's judgment that counts, not only in the performance of his duties in the engine room, but in his administrative position as the head of an important department.

His vocation is unique in that there is no well defined term by which to designate it. If it were only a matter of keeping boilers and machinery in operation, starting and stopping, and looking after details, he might be called an attendant, but if he is to be truly successful he must have more than the ability to do these things. He must have mechanical ability as a workman, as well. This part of his work savors of a trade. He must also have a knowledge of mathematics, physics and chemistry before his calling takes on the characteristics of a profession.

Then there are the things learned by experience; they are peculiarly the property of the engineer. They increase his knowledge and better his judgment in his routine work, and that is a strong point, but his knowledge cannot stop here. It must extend to the executive end of his duties and covers what is now a very important part, and what is fast becoming more important—the business part of his work. To know what is best in his plant to get results, that is what the employer wants, and it requires a knowledge of uptodate equipment of apparatus, appliances and devices, as furnished by trade papers, circulars and catalogs and by personal investigation, and finally, it requires good judgment in the selection of those best suited to the conditions of his own plant.

A man may have all this at his command, but the "what" and "when" in the matter figure largely. He must work in harmony with the powers that be. A proposition that might not receive encouragement at one time might be sought for at another. The management has other things to look after besides the power end, and the engineer must use good judgment in his relations therewith. Knowledge and experience improve judgment, and they are both valuable assets to the engineer.

Engineering Points in Court Decisions

The doings of the civil courts are thought by many engineers to be about as uninteresting as any human activity can be. That this is a mistake will be discovered by anyone who will take the trouble to glance through a few volumes of decisions handed down by the supreme court of any state having a large industrial population. Scattered through the pages of these publications are many absorbing "stories" of both human and scientific interest, and the engineer who has never made the acquaintance of opinions of this kind will do well to look into the subject the next time he is in a public library or within visiting range of a courthouse.

Naturally, the chief engineering interest centers in those decisions which bear most directly upon accidents, except in the findings of the Federal courts, where patent decisions of the most absorbing technical significance may be found. By and large, these decisions contain clear-cut statements of the circumstances surrounding accidents in the plant and on the field which are often instructive in suggesting ways of avoiding the recurrence of trouble, and which almost invariably assign responsibility in a way which appeals powerfully to men with the reasoning powers of engineers. It is surprising how soon one can acquire the knack of scanning decisions of this kind for material of technical importance from the engineering or operating standpoints, and the excellent indexes which these volumes generally have are most helpful.

Without attempting to list the topics treated in the findings of the higher courts, it may be noted that these include explosions, short-circuits in electrical generating equipment, accidents on transportation and distributing systems, failures of material due to defective manufacture, the results of negligence in dealing with high-tension conductors, omission of safeguards on and around machinery, failure to live up to the terms of contracts, oversights in the erection and use of structures, tools and forms for concrete molding, the value of new ideas in equipment design and arrangement, and a host of other matters which make very interesting reading, entirely apart from the discussions of legal problems which necessarily go with the setting forth of facts and the interpretation of their relations to one another. Especially in the patent cases is one likely to find engineering points of note, since expert testimony is usually brought into the proceedings and the analysis of equipment designs carried to extraordinary lengths.

The study of court decisions bearing upon engineering questions is well worth the while of men of technical training and occupation, and it is a pity that so many engineers fail to realize the interest and instructive value of the material hidden away in such opinions. Court decisions will never rank among the "best sellers," but no greater mistake could be made than to assume that they are too dry to be worth scanning except in cases with which one has personal associations. If one does nothing further we would advise at least the reading of the digests of cases of engineering interest which appear from time to time in our department, "Recent Court Decisions."

Analyzing the Plant's Condition

It is always gratifying to the editors to know that readers have made practical use of matter which has appeared in POWER's pages. Under the same heading as this editorial, on page 239 is the report of a reader on his plant, as examined according to the questions in the foreword, "A New Year's Letter," which appeared in the issue of January nineteen.

Incidentally, Mr. Hawkins is to be complimented on the excellent showing which his plant made. We are satisfied, however, that it was not for the purpose of eliciting praise for himself or his plant that he sent us this report with his permission to print it, justifiable as may be his pride in the condition found. Rather do we believe that he is sincere in hoping that the idea may be of value to others who would take it as a suggestion to measure their own plants, not so much to discover how well they have done, but wherein they may make improvements.

In his own case it would appear that Mr. Hawkins has been frank in his criticism of things that are not all that they might be, and it is in this direction that we feel he and all who try the test will derive the most benefit. In fact, it was our purpose in printing the New Year's letter to have it bring to mind all of the points upon which an examination of a plant is desirable. While most of them would occur to any painstaking engineer, a few might easily be overlooked.

The scheme of marking or grading the condition by percentages for each question was rather original and has its value to any individual, as it affords comparable figures. It would not, however, serve as a basis for comparing different plants, at any rate not unless the marking were done by the same person, on account of the personal factor entering in. No two people would judge alike. Further, as Mr. Hawkins pointed out, the average percentage of the plant as a whole is not fair while equal weights are allowed to each question and answer. To carry out that plan relative importance of one thing to another should be taken into consideration. It is also evident that two different plants could not be justly compared without some modification of the marking system. The scheme does have value, however, in comparing the condition of the same plant from year to year.

We believe that good may come from a discussion of the idea and will welcome suggestions for elaborating or improving upon the method of plant analysis.

Soot

Soot lowers the heat-absorbing efficiency of boiler-heating surfaces! Soot obstructs the passage of the products of combustion! Soot is a direct cause of corrosion! And soot is smoke! Altogether, soot is the undesirable of the boiler plant, an enemy of efficiency that is always present and cannot be entirely eliminated, but must be limited if economy in steam generation is to be realized.

As a destroyer of boiler efficiency, soot is more potent than would be five times the thickness of asbestos spread over the heating surfaces. In obstructing the passage of gases it not only reduces the area of free passage, but the soot clinging to the heating surface has a marked retarding effect on the flow of the gases in proximity to the heating surfaces, thus further reducing the rate of heat transfer to boiler contents. Corrosion of boiler tubes and surfaces is accelerated by deposits of soot, either through electrolytic action or the eating away of the metal by the sulphur constituents that are present, to some extent, in all soot. Then soot contains, or is, practically all the visible, wasteful and objectionable constituents of smoke. Within the furnace, boiler and flues soot is merely soot; issuing from the chimney it is black smoke.

Suppose that, as some claim, one thirty-second inch of soot on the heating surfaces produces as great a loss as blowing out a pound of steam for every ten pounds generated. Steam escaping into a boiler room at any such rate would soon make it impossible for the fireman to remain near his boiler and would be such an evident sign of waste that it would not be countenanced in any plant, no matter how slipshod its operation. Nevertheless, a mean thickness of one thirty-second inch of soot may be found on the heating surfaces of many a boiler—it will frequently collect in ten hours' operation. Again, assume that a three-sixteenth-inch coating would be as detrimental to efficient operation as throwing away seven pounds of steam for every ten pounds generated, which, if allowed to escape into the boiler room, would quickly scald to death the boiler-room force or bring about their asphyxiation. Three-sixteenths inch of soot is rarely found clinging to all heating surfaces, it is true, but such accumulation is not unknown in out of the way corners of the boiler, corners that are difficult to cleanse of soot.

Perfect combustion of fuel would be the only way of eliminating soot. This being impossible of realization, every means of improving combustion must be taken and the heating surface of the boiler frequently cleaned. Too great efforts to prevent soot accumulation cannot be made, for it surely and continually settles on every surface that lies in the path of the products of combustion.

Correspondence

A Short Cut in Packing

One way to cut down Sunday work is to have packing ready cut and prepared to fit each gland. It should be kept in boxes labeled with the size and the rod it is cut for. It is also a good plan to keep the packing hooks on a rack in the same locker, then with a good heavy pair of gauntlet gloves an extra ring of packing can be slipped in during the noon hour. When a job of this kind is to be done in a limited time, it is most important to have everything ready before the machine is shut down. Then, just as soon as the machine is stopped, get busy. The heavy gloves protect the hands, and with all the tools laid out within reach and in order, the job does not take long.

A. D. WILLIAMS.

Cleveland, Ohio.

Analyzing the Plant's Condition

As I read the "New Year's Letter" on the first page of the issue of Jan. 19, I mentally answered the questions asked, as they applied to our own plant, and after finishing the letter the question arose in my mind, "Assuming the best practical operating conditions to be 100 per cent., what percentage, as an average, will our plant show?" The result of this self examination was interesting, and the method in which it was made may be of use to others desiring to make the same test. Each question was considered on its own merits, keeping in mind as a standard the best practices as advocated in the columns of POWER during the past year.

	Per Cent.
1. Are our boilers clean? Yes	98
2. Is the brickwork in good condition, and are all cracks and unnecessary openings air-tight? Some cracks in setting	98
3. Is the feed-water heater clean and working efficiently, and is the water as hot as possible? The heater is clean, but not of an efficient type. Exhaust is also used for heating the building, and hotter feed water would mean more live steam for the building. Could be improved in summer	94
4. In water-tube boilers do we know that the baffling is tight and that the gases are not short-circuited directly to the stack? Yes	100
5. Are we sure that all blowoff valves are tight and that we are not blowing down too much? Yes	100
6. Are our dampers working, and do we use them instead of closing the front doors on hand-fired boilers, allowing cold air to filter through the brickwork, etc., or on stoker-fired boilers allow the fires to burn down too low? No. Dampers are not properly used. Draft is controlled by speed of stoker engine and fan, and is unsteady	80
7. Are we carrying a steady maximum steam pressure? Yes	100
8. Are all our grates, gages, flue cleaners and other boiler- and engine-room tools and auxiliaries kept in proper condition? Yes	100
9. Have the soot and ashes been cleaned out of the base of the stack and combustion chamber? Yes	100
10. Do we know that our draft is the maximum possible under the existing conditions? It is too high	98
11. Are we using a minimum amount of labor to properly perform the work in both engine and boiler rooms? Yes.	100
12. Are the engines operated as economically as possible under the existing conditions? Yes	100
13. Do the pistons leak? No	100
14. Do the valves leak; are they properly set? There is no leakage, and they are properly set	100
15. Is there any undue loss of pressure between the boiler and engine? No	100
16. Is there any steam loss from leakage in steam lines? No	98
17. Is the back pressure on the exhaust a minimum? Could be lower in winter, but would give no better economy, as engines are not intended to operate on a vacuum	98
18. Are all steam traps in good condition, or are valve seats cut, floats collapsed or other parts defective? Holly drain system is used, with very few traps; these are in good condition and do not leak	100
19. Are all exposed surfaces subjected to loss of heat by radiation covered? Yes, except pipe flanges	94
20. Do we know that all valves on steam lines and all drain valves are tight and in good condition? Yes	100
21. Are all drains from oil separators, heaters, piping, etc., clear and in good order? Yes	100
22. Are we using the proper auxiliaries to keep the feed-water temperature at a maximum, and are motor-driven auxiliaries operated under a maximum efficiency? In winter, yes. In summer we could do better with a more efficient type of feed-water heater, as the exhaust is wasted and the temperature of feed-water in summer is low	85
23. Have we the maximum vacuum possible with the present temperature of water, barometric head, and water supply? No, a higher vacuum could be carried in winter, but more live steam would be used. In summer engines run noncondensing	96
24. Do we keep the maximum load factor on all apparatus in use? Yes, on boilers, but engines operate a great deal of the time underloaded. Have one more unit than is needed and smallest unit is too large for the light load at night. Only one is used at a time	80
25. Do we try to keep down the cost of supplies such as lamps, oil, waste, packing, etc.? Yes	100
26. Do we know that our apparatus and station light and wiring are in safe condition? Yes	100
27. Have we fire extinguishers and fire hose on hand and properly connected? Yes	100
28. Have we taken all precautions to prevent accident by protecting all openings by railings, inspecting ladders to see that they are safe, looking after all weights or other heavy parts that may be suspended from above, seeing to it that all pulleys, blocks, tackle chains, and other tools are in proper order? Yes	98
29. Are there any oily or slippery places in or around the plant, or any piping or apparatus in use that is showing signs of strain? No, except high pressure in feed line due to leaking pump governor	98
30. Are high-tension apparatus, switchboards and all exposed wiring properly guarded and danger signs used where necessary? All wiring is protected by guards except front of generator switchboard, and wide space back of distribution switchboard is used for storage of lamps, wire, etc	90
31. Have we prepared for extreme weather conditions in the way of ice, floods, lightning, etc.? Yes	100
32. Have we taken care of the effects of high wind and rains on our stacks, windows, roofs, etc.? Yes, except main sewer from building is too small and causes water to back up through plumbing fixtures on basement floors during very hard and long rains	95
33. Do we keep accurate records of the operation of the power plant and other machinery? Yes, but could be improved	98
34. Is the operation of the plant harmonious, the men satisfied with their work and with each other, and with the salary received? Yes, as a rule	98
35. What is the general appearance of the plant; is it kept clean, with bright work polished, floors clean and all machinery clean? Yes	100

Adding the percentages for each item and taking the average, we get a general average of 97 per cent., or in other words, the general condition of the plant taken as a whole has a rating of 97 per cent. of the best practical operating conditions that could be obtained in a plant of this character. The nature of the work is that of an office-building plant. We have a greater engine capacity than is required and could get along just as well with one less engine. The other equipment is all required to provide continuous operation. The lowest percentage of any part of the equipment is in the furnaces, which could be improved by installing a better means of controlling the draft and by operating the blower continuously at a uniform speed, with the dampers partly closed at times. There are some other changes that could be made to improve the efficiency, but would require a change of the equipment in use at present.

This test, if honestly made, is interesting, and of benefit in checking the general condition of the plant at the end of the year. If it were made at the beginning of each year it would give the engineer an efficient means of telling whether the condition of the plant was getting worse or better, as compared with previous examinations.

It has the disadvantage that a low percentage in the boiler efficiency would be more expensive than a low percentage in the condition of the fire extinguishers, for instance, but would not show in the general average unless the several percentages were multiplied by their relative importance.

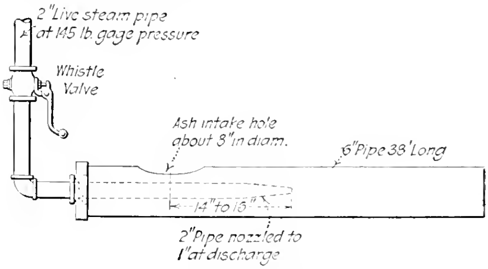
I would like to know what other engineers think of this self examination, which I admit is not absolutely correct from all points of view, and what they would suggest to improve it.

J. C. Hawkins.

Hyattsville, Md.

Live-Steam Ash Ejector

In regard to the unsatisfactory ash ejector described in the issue of Dec. 22, 1914, p. 889, I would suggest that if Mr. Clark will advance his steam nozzle to about 16 in. beyond the intake of his ejector, or, in other words,



Nozzle for Ash Ejector

beyond the bottom of the ash hopper, and use a 2-in. steam pipe nozzled down to 1 in. at the discharge instead of a bell nozzle, and entirely close the end of his larger pipe where the steam pipe enters, he will undoubtedly eliminate his ejector troubles.

In a plant where I was once employed we had almost the same trouble, and changed it to something like the inclosed illustration, and the ejector worked very well; but it did not have the capacity needed for the four boilers, which it was intended for, so we made two of them and the trouble was ended.

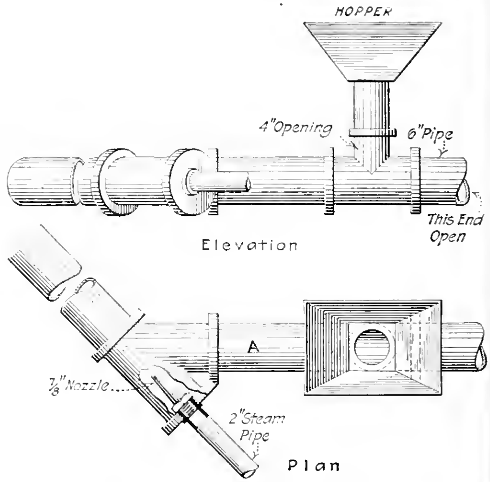
H. L. Burns.

Oran, Mo.

I think if E. H. Clark would change the plan of piping a little and increase the size of the steam pipe the ejector would probably be a success. In his arrangement I believe the steam helped to clog the pipe instead of clearing it.

In the arrangement shown in the accompanying illustration, the steam jet creates a suction in the pipe *A*, which pulls the ashes from the hopper, and they have a high velocity when they reach the nozzle which blows them on through the pipe. If the end of the pipe were not open the ashes fed into the hopper would clog up.

I know of an arrangement similar to this one, which is in successful operation, and I think it is worth a trial, as it would only require a Y-fitting in the present line



Another Steam Ash Ejector

a few feet ahead of the hopper and a larger steam pipe with a single nozzle—one made of brass I think is the best. The pipe line must be air-tight back of the nozzle except at the open end, as noted.

G. Clevenstine.

Pottstown, Penn.

Motor Had One Terminal

Where motors or generators may be required to operate in either direction, both the armature terminals and the field terminals are brought to the outside of the frame for convenience in connecting. Shunt- and compound-wound machines may have four, three or two terminals brought to the outside. Where there are four, all connections are to be made outside, and where there are three,

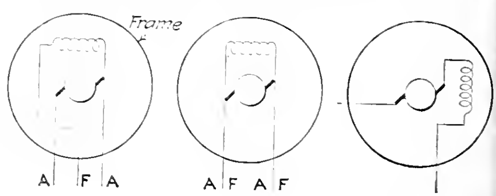


Fig. 1. Fig. 2. Fig. 3.

one armature terminal and one shunt-field terminal are connected inside, as indicated in Fig. 1. This connection may be found on generators, the rotative direction of which has been specified. Where there is but one pair of leads issuing from the frame, it means that the armature terminals and field terminals have been paired and connected inside the motor, as indicated in Fig. 2. Such a connection is never found on machines as received from the makers, because, in the case of a motor, it would require starting with the shunt field short-circuited by the armature; and, in the case of a generator, there would be no convenient way of cutting in the field rheostat.

The limit in terminal economy was reached in the case of a series motor operating a line of shop shafting. The motor apparently had but one terminal; that is, only one terminal issued from it. This condition had passed unnoticed until the motor developed an open circuit which had to be located. The motor was supported by an iron shelf bolted to the iron building, traversed by the car tracks and, upon disassembling, it was found that one armature terminal had been connected to one end of the series field and the other armature terminal was brought out for external connection, as indicated in Fig. 3. Instead of the other end of the series field being brought to the outside of the motor, it was connected to one of the iron field shells with a bolt and the connection taped over, so that it could not be seen. The open circuit was due to the bolt having loosened and burned off.

J. A. Horton.

Schenectady, N. Y.

Compressor Gaskets

In the Nov. 10 issue, Christian L. Hern inquires for a suitable gasket for ammonia-compressor valves. I have had satisfactory results with gaskets made from pure tin or from solder, half tin and half lead. Make this up in the shape of a cylinder by forming up sheet metal an inch or so larger in diameter than the gasket and six or eight inches long. Inside of this use a mandrel about ½ in. smaller than the gasket. After pouring, chuck in a lathe, bore and turn to the inside and outside diameters of the gasket and then cut off to the proper thickness. These gaskets have always made tight and lasting joints for me.

Perry Losh.

Muncie, Ind.

Safety-Valve Specifications

The article in the Jan. 19 issue, page 81, under the above heading, brings out a number of interesting points in the proposed boiler code of the A. S. M. E. It would appear that these specifications, formulated by the manufacturers of safety valves, represent the best modern practice embodying the combined experience and judgment of those who have had the best opportunities for studying the subject. While in the main the specifications cover the subject in an excellent manner, there are several points which, looking at the matter from a practical standpoint, seem a handicap to the code and impossible of fulfillment.

Assuming that the code is adopted and placed before the legislature of a state, the promoters of the bill will have a hard enough row to hoe to convince steam users and other taxpayers of the desirability of legislation along these lines as a public safeguard. It will be hard to convince legislators in states where boiler laws similar to the proposed code are now in force that anything will be gained by discarding the present rules in regard to safety valves and adopting the code rules. Other states which might be favorably disposed toward this legislation would await the action of the states which now have boiler rules and, undoubtedly, would act along the same lines as the pioneers. It would seem, therefore, that in loading the code with fine-spun theories and lofty ideals the safety-valve manufacturers have not given full consideration to the practical side of the matter.

In the proposed code the size of a pop safety valve for a boiler is based on the discharge capacity of the valve. To determine this capacity it is necessary to take into consideration the total weight, in pounds, of fuel burned per hour at time of maximum forcing, the heat of combustion in B.t.u. per lb. of fuel used, diameter of the valve seat in inches, the vertical lift of the valve disk measured immediately after the sudden lift due to the pop, and the absolute boiler pressure per sq.in., or gage pressure plus 14.7 lb.

A study of these requirements suggests many interesting questions which affect the practical application of this rule. How can it be determined when a boiler is being forced to its maximum capacity? Take, for example, a hand-fired return tubular boiler on which a good fireman with high-grade fuel is having a struggle to maintain steam pressure. Now, if an automatic stoker were installed on this boiler, more work could be obtained from it before the same conditions would obtain. It might be that several types of stoker would be tried out, each doing a little more work than the one preceding it, before the right one was found. In each case, however, the boiler or, rather, the furnace would have reached its maximum capacity and, undoubtedly, the safety valve would have been changed each time. Take the case of a locomotive, in which the maximum capacity is only attained when the engine is being worked. In this case the greater part of the steam goes through the engine and the safety valves are never called upon to take care of the maximum evaporation of the boiler.

The heat of combustion of the fuel would, of course, be determined by calculations from a chemical analysis or by burning a sample in a calorimeter. If fuel is tested today there is no assurance that subsequent tests would not show a higher value, possibly to such an extent that a change of valves might be required to conform to the code. A great many steam plants have no coal-storage capacity, and the coal is delivered day by day as required, and many an engineer can tell without a calorimeter that the heating value of the coal varies load by load.

In the case of a number of paper mills in the Middle West, the principal fuel is "hog feed," or wood chips. The boilers are equipped with stokers which are always ready to go into service automatically if the supply of wood fuel decreases and the steam pressure tends to fall. In one of these plants they have six 90-in. by 20-ft. tubular boilers, and burn about five tons of coal a week in addition to the wood fuel. Now, under the code the safety valves would have to be proportioned, not on the normal conditions, but on the theory that the boilers were being forced at all times to their maximum with coal as fuel. Many similar instances could be cited where it is frequently found necessary to make a quick change in the nature of the fuel.

The vertical lift of a safety-valve disk can be determined by a laboratory test involving delicate registering and recording instruments. If the valve lifts a certain amount, expressed in thousandths of an inch, today, what assurance is there that it would not lift a few thousandths of an inch more or less tomorrow, making the test valueless?

At the top of page 39 of the code, a table of values is given, which may be assumed as the heat of combustion of various fuels. If it is fair to assume this value, why not assume a value for each of the other variants in the rule or formula, which would bring us back very closely to the rule now in use in Massachusetts and Ohio? This could be modified, if necessary, by the addition of the paragraph in the rules of Ontario and other Canadian provinces which provides that, when considered necessary, the safety valves shall be tested under full steam and full fires for at least fifteen minutes with feed water shut off and stop valve closed; if the accumulation of pressure exceeds 10 per cent. of the working pressure of the boiler, a larger safety valve must be substituted.

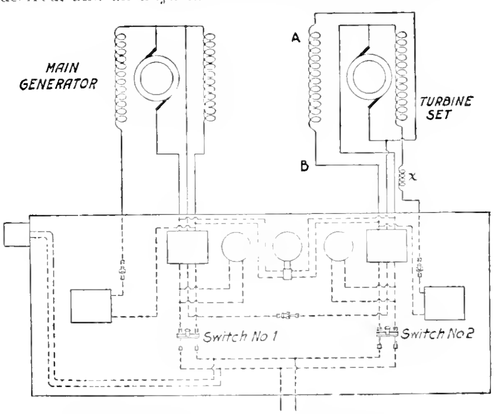
By this means the whole purpose of a safety valve would be fulfilled and steam users, inspectors, and boiler manufacturers would have a reasonable idea as to where they stood on the safety-valve proposition.

GEO. E. PERKINS.

Brooklyn, N. Y.

Neglected to Change Field Connections

In taking off some indicator diagrams from an engine we had occasion to put on an additional load. For this purpose it was decided to run a small turbine set as a motor. The main generator and the turbine set had been so arranged that they could be connected in parallel if desired, and an adjustable resistance was inserted in the



CONNECTIONS BETWEEN THE TWO MACHINES

armature circuit of the turbine set at X to limit the flow of current when starting as a motor.

When switch No. 2 was closed and the resistance gradually cut out, the resulting current flow was so great that the belt driving the main generator began to slip; finally, it came off. The trouble was at once laid to a short-circuit in the turbine-generator circuit running to the switchboard. Testing out showed the circuit to be free from shorts, and after carefully looking over the field connections of the turbine set, it was found that the series field connections A and B had not been reversed for operation as a motor.

The turbine-generator had a large series field effect. When the switch was closed and the resistance was being cut out, the current, flowing through the series field in an opposite direction, produced a differential action and neutralized the flux produced by the shunt field. As the torque is the product of the field strength and that of the armature, and the starting torque required was large, the armature revolved very slowly. Hence, the counter-electromotive force was low and permitted abnormal current through the armature.

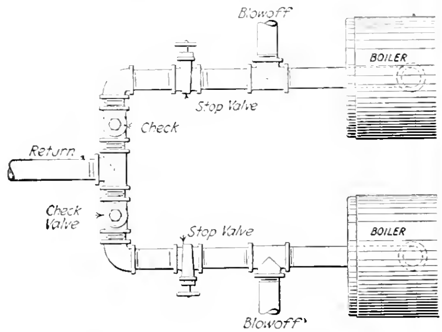
After the necessary changes were made no more trouble was had and the engine tests were made with excellent results.

CARL E. EISMANN.

Rexford, N. Y.

Lack of Synchronism in Check-Valve Action

Referring to the article in the issue of Jan. 12, page 48, under the above caption, it appears that the final arrangement, which gave satisfactory results, was to leave the four heated vessels connected to a main return line with only one check valve in the same.



PROPOSED HAND-REGULATED RETURNS

As regards the Massachusetts rules, which propose to require a separate check valve in each return line for heating boilers connected two or more in a battery and fired independently, it would seem that there is no analogy between this proposed method of connecting boilers and the boiler in question, which furnished four unfired vessels with steam.

In the case where one check valve is used on the main return line, if one boiler is furnishing most of the steam, while the fire under the other is banked, the water will tend to flow through the return connection away from the boiler which does the work, due to the slightly higher steam pressure. The function of separate check valves in each return line is to prevent this. The illustration shows how the connections should be made. With separate checks in each return line, the water level in the boilers will vary with the rate at which each boiler is forced, but would, however, be controlled by the stop valves shown, similar to the ordinary feed valve, so that if the check valves did not work in synchronism it would make no material difference, for the water level would be controlled entirely by the stop valves.

A. W. MACNABB.

Newark, N. J.

[Regulating the water level by stop valves as suggested, would require someone in constant attendance, which is not often the case with small heating plants.—EDITOR.]

Record Keeping in the Power Plant*

SYNOPSIS—The importance of keeping accurate daily records and the necessity of analyzing and comparing them. Losses which would otherwise go by undetected are discovered and the saving in the course of a year is well worth the trouble.

Occasionally one finds a plant in which fairly complete daily records are kept and a capable man in the capacity of supervising engineer to make daily comparisons of operation of the furnaces, boilers, engines, generators, etc., but it is probably an exception to the rule, particularly in the smaller or medium-sized plants.

It is usually difficult, and frequently impossible, for an engineer to persuade his manager to furnish him with the necessary instruments and devices to make daily tests on operating conditions, and the necessary printed forms on which to record the data for purposes of comparison and for detecting the location, or even the existence, of preventable losses. Yet the writer's experience with several plants has proven that the savings made in one month as a result of the daily tests and records frequently will pay for all the additional expenses incurred within a year.

In nearly all plants managed by the writer he has insisted on installing scales to weigh all coal as used and the ashes daily, a water meter in the boiler feed line to measure all water fed to the boilers, a kilowatt-hour recording meter to measure electrical output, and suitable printed forms on which to record the daily records of pounds of water evaporated per pound of fuel, pounds of refuse from furnaces and its percentage to the total fuel, pounds of fuel consumed, rate of combustion, electrical output, pounds of fuel per kilowatt-hour, boiler output in horsepower hours of operation, steam pressure carried from recording gages, and similar data which local conditions would suggest.

These records should be as complete as the nature of the plant justifies; some types of plant naturally require more data than others, but in all cases sufficient data should be recorded to make daily comparisons of value in detecting losses which may arise within the course of a few hours.

From these daily records suppose it is noticed that the boilers evaporated 6 lb. of water per pound of fuel today, while yesterday 7 lb. was evaporated; there is a cause for this difference, and the right kind of a man will not be satisfied until he finds it. It may be due to a new car of fuel, the quality of which is not as good as the former car; perhaps the firemen were "too busy" to scrape the boiler flues. Show them how to be more systematic, so that they will always have time for this work and show them conclusively that you know what is going on in the boiler room and cannot be fooled. Perhaps the load was lighter—then take the matter up with the works manager and try to persuade him to balance his operating conditions to better advantage. Some boiler plants are so located with relation to adjoining buildings that when the wind is from certain directions the draft is affected, materially reducing the furnace efficiencies. Notice from the records if this applies to your case; if so, estimate the losses during a month from this cause and then figure out how long it would take the possible savings to pay for an addition of 50 ft. to the stack. Then put it up to the general manager. There is always a cause for every effect; the records show the effect, and it is up to you to locate the cause and remove it as soon as possible.

Suppose the records show the number of pounds of fuel per kilowatt-hour to have been six yesterday and four for the day before; why this difference? Assuming the load conditions and the boiler evaporation to be the same for the two days, there evidently has occurred a change in the engine economy. This may be due to one or several things; get busy and find the cause.

It is not always easy to locate the immediate cause of these variable losses, but daily analysis of operating performances will soon make a man quick in running down the trouble and will train him to take the necessary steps to prevent their recurrence.

The knowledge that someone is daily going over the operating records also has a decided effect on the engineer and fireman. At first these men usually resent the idea of being so closely watched, but by taking them into your confidence, showing them the various records, complimenting them upon securing better results, and consulting with them in the effort to locate undue losses, they soon learn and realize that this watching is of personal benefit to themselves and adds to their store of knowledge. Usually, there will be voluntary competition between shifts and between neighboring plants to see who can get the most work out of a pound of fuel.

Of course, the writer has found men who resorted to tricks to fool him. One fireman thought that blowing off the boilers at light-load periods and letting in fresh water would raise the rate of evaporation. It did slightly, and sufficiently to start an investigation of the steam consumption of the engine, as at first it appeared that it was taking more steam than ordinarily. The engineer, of course, was notified of an apparent loss of economy in his engine, and after checking the rate carefully he became busy in trying to solve the peculiar problem of the boilers' apparently generating more steam than the plant was consuming. He found the cause and discharged the fireman.

Another fireman was complimented when his rate of evaporation showed an improvement. By permitting the safety valve to open frequently he raised the rate of evaporation, but wasted fuel in doing so. Two or three days' record were sufficient to put a stop to this practice.

The writer believes in frequent testing for line-shafting losses. The tests are simple and inexpensive, especially in case the plant is group-driven by electric motors. The daily hunting for preventable losses is less expensive than the ignoring of them. The load conditions seriously affect the efficiencies of furnaces, boilers, and practically all engines. It is desirable to pay attention to this point and attempt to persuade the works manager to better balance his production departments. One hour or day the power plant may be seriously overtaxed, while the next hour or day it may be carrying a decided underload. Usually, these conditions can be avoided or at least improved upon.

A few years ago the writer took charge, as supervising engineer, of an isolated plant which was entirely too large for the work required. The load factor at that time was about 18 per cent. of the engine and generator rating, and as a result the losses were large. The engine was a simple Corliss, belted to an alternating-current generator, and the boilers were of the regular horizontal return-tubular high-pressure type. The engine was operated at 108 r.p.m., but an order was issued immediately for the proper pulleys for the generator, engine and governor to drop the speed to 82 r.p.m. The result was a saving of 25 per cent. in coal consumption. The only apparent solution for better economy was more load. The shop was fully equipped with men and machinery, so there was no chance for more load here. The rate of evaporation of the boilers was approximately 3 lb. of water per pound of coal. Evidently, then, there was a chance for improvement in the boiler room.

Gas was used for heating the baking ovens in the japanning department, and the writer designed and built in the shop an electric oven. It was so successful that six more were built within a short time. This electric-oven load was just what was needed to bring the load factor up to 41.4 per cent. of the plant rating, and gave the boilers more work to do, with the result that the evaporation increased to 6.5 or 7 lb. of water per pound of fuel. As the rate of evaporation more than doubled with this increased load, it required actually less fuel to operate the plant and saved between five and six dollars for gas per day.

There was still a loss not located, and it was logical to expect it to be in the furnace. Each furnace had 30 sq.ft. of grate area, and tests showed that the rate of evaporation was highest, other things being equal, when from 18 to 20 lb. of screenings were consumed per square foot of grate per hour; a decrease in this rate of combustion, or an increase, lowered the rate of evaporation, the latter showing a greater loss.

Previous tests on the boilers showed that their evaporative efficiency fell rapidly from half load to no load, while the curve of evaporation from one-half to 1¼ load was fairly flat. As the load was sufficient to require in one boiler a combustion rate of about 35 to 40 lb. of fuel per square foot of grate, the furnace efficiency was low. If both boilers were operated to gain in furnace efficiency, the boilers were so underloaded that they showed poor efficiency. Evidently, it was a question of increasing the height of the stack, using forced draft, or adding to the grate area.

A higher stack or a suitable forced-draft system would have increased the economical rate of combustion, but the in-

*From a paper by S. J. H. White presented at the annual convention of the Indiana Engineering Society in Indianapolis, Ind., Jan. 21 to 23, 1915.

crease in grate area seemed worthy of trial, and new grates having an area of 36 sq.ft. were installed in one furnace. This resulted in some saving during the daytime, but at night, when the load was light, the losses were greater than with the smaller grate area. The net gain, however, was considerable.

At this time the company was contemplating moving to another city, so that the writer did not recommend a higher stack, which, after all, was the proper solution of the problem, as it is in a great many plants.

The daily losses detected and removed by a careful survey of the records amounted to over $1000 per year on coal costs alone, with an output of approximately 231,000 kw.-hr. This reduces to 4.3 mills per kw.-hr. and is about 31 per cent. of the total cost of production, including fixed charges, or about 70 per cent. of the cost per kilowatt-hour for fuel, labor, oil and waste only. The cost per kilowatt-hour during 1913 in this plant, including fixed charges of 14 per cent. on the investment, fuel, labor, oil and waste, was $0.014. In view of the fact that the load factor was only 31.4 per cent. of rating, the writer considers this an excellent record, and one which it is possible to make only by the closest supervision.

The weighing of coal proved to be valuable in another way. The management closed a contract for coal with a certain dealer. The writer detected a decided difference in the quality of the coal and a shortage of weight after the third car had been shipped on this contract. He reported the matter and made complaint, but the matter was not attended to as it should have been. Inside of a short time the company had been billed with 70,000 lb. of coal which it had not received. In other words, the weights on the bills had apparently been raised 10,000 lb. per car, and further, the coal was not shipped from the mine specified in the contract. The daily records showed this up clearly. Without them, how much would have been lost on short weights alone in a year's time, to say nothing of the losses resulting from the rate of evaporation dropping from 6.5 to 4.5 lb.? The contract was canceled, and coal was purchased elsewhere of a much better quality on a square-deal basis.

The facts given show that it pays to keep records. Never be satisfied with results which may seem good, but which may possibly be improved upon. In all lines of work continual digging is the only successful way to secure the best results.

Watt-Hour Meter Accuracy*

By D. D. Ewing

While approximately one-half the states have passed laws authorizing the creation of public-utilities commissions, many of the commissions are as yet in the formative stage and have not passed any regulations on watt-hour meter accuracy and meter testing. The percentages of error allowed by the commissions of several states are:

State	Permissible Error, Per Cent.	Remarks
New York	4	Meter must not creep on 110 per cent. voltage.
New Jersey	2 fast, 4 slow	
Connecticut	4	
Maryland	4	
Indiana	4	
Massachusetts	5	
Wisconsin	4	
Washington	4	

The following requirements, abstracted from the rules of the Wisconsin commission, have been widely copied in other states:

(a) No electric meter which registers upon no load shall be placed in service or allowed to remain in service.

(b) No electric meter shall be placed in service or allowed to remain in service, which has an error of registration in excess of 4 per cent. on light load, half load or full load.

(c) Each service meter shall be tested at least once each year, the test to be made by comparing the meter while connected in its place of service, with suitable standards on light-load, half-load and full-load rate of operation.

(d) Each service meter shall be tested and adjusted for accuracy at the time of its installation.

(e) A complete record shall be kept of all tests made on electric meters.

(f) Each company supplying electrical energy on constant-potential systems shall adopt and maintain a standard average value of voltage, as measured at any consumer's cutout, which shall remain constant from day to day, and vary during any one day by an amount not more than 6 per cent. of the minimum value.

It is interesting to note, in this connection, that the permissible error in gas meters, as defined by the regulations of most of the above named states, is only 2 per cent., despite the fact that electrical quantities are capable of more precise measurement than is the flow of gas.

The question may be asked: How near do the meters on the market conform in accuracy to the requirements of the regulations? Manufacturers of direct-current meters usually claim that their meters will register within 2 per cent., plus or minus, from 5 per cent. of full load to 50 per cent. overload, the meter being capable of carrying the overload continuously. Some makers place the lower load limit at 10 per cent. instead of 5. The lower load limit with alternating-current instruments varies from 2 to 5 per cent. of full load among the different manufacturers, the accuracy and overload limits being the same as for the direct-current meters.

The initial accuracy, or accuracy when new, of most modern meters is largely a matter of adjustment. In fact, by careful adjustment a good meter may be made to give an initial registration within 1 per cent., plus or minus, from 2 per cent. load to 50 per cent. overload, and a registration within ½ per cent. from 10 per cent. load to 50 per cent. overload. Such very careful adjustment is hardly a commercial feasibility, however, as it would make the first cost of the meter too high. Moreover, the maintenance charges would be excessive if such a high grade of adjustment were maintained.

Most types of meters are fairly accurate when new, but permanency of calibration is one of the most important of the features that distinguish the good meter from the poor one. In the modern meter increase of friction is the factor that most often affects the permanency of calibration. Also, the variation of the meter friction from instant to instant makes it difficult to secure consistent results in light-load tests. The effect of increased meter friction is to make the meter run slow. With a well designed and constructed meter, it is the exception rather than the rule that the percentage registration increases as the age of the meter increases. While increased friction tends to make the meter run slower at all loads, the effect is most marked at light loads.

Evidently, no power company would care to keep in operation a meter in which the friction had increased enough to even slightly affect the full-load registration. With meters of lower torque ratio than 200 to 1, the errors will be greater, other things being equal. However, if a well designed and constructed meter is properly installed, the friction does not increase very rapidly.

A comparison of the rules above abstracted with the operating characteristics of the meters leads one to believe that in general the regulations cover the ground fairly well. There are several points, however, that merit further discussion. Rule (d) is hardly specific enough and, as it stands, is capable of broad interpretation. It does not specifically state that the test is to be made either on the consumer's premises, with his load or a load having similar characteristics, or elsewhere under conditions approximately similar to those on the consumer's premises, and be in service a year before the error in calibration was discovered. In rules (b) and (c) light load is not defined. If a meter is adjusted so that it is registering within the limits of permissible error, as fixed by the rule, at 10 per cent. load, the error at 2 or 3 per cent. load may be anywhere from 5 to 15 per cent.

The ruling that electric meters may have an allowable error of plus or minus 4 per cent. does not seem consistent with the 2 per cent. ruling for gas meters. It seems that a ruling allowing the permissible error on 5 per cent. load to be 6 per cent., and the error on half and full load to be 2 per cent. would be much better. Such a ruling would protect the consumer far more than does the straight 4 per cent., because with the latter all meters can be adjusted by the power company to be approximately 4 per cent. fast at the higher loads, because meters have a tendency to slow down with age rather than to speed up. At the same time such a ruling would not work any particular hardship on the public-service companies because the light-load error passes the 6 per cent. point long before the error at full load would pass the 2 per cent. limit. Also, some time would be saved in meter testing, because the variable friction of the meter makes it difficult to secure consistent results at light loads, and with a wider range of permissible error at light load, meters would not have to be tested so often.

*From a paper read before the Indiana Engineering Society at Indianapolis, Jan. 21 to 23.

In conclusion, the writer believes the efficiency of the commission rules above abstracted would be increased if:

(1) They specifically stated that meter tests made on the customer's premises be made either on the customer's load or a load whose characteristics were known to be approximately the same.

(2) Meter tests made elsewhere than on the customer's premises should be made with the conditions of voltage and power factor as near like those existing on the customer's premises as is practically possible.

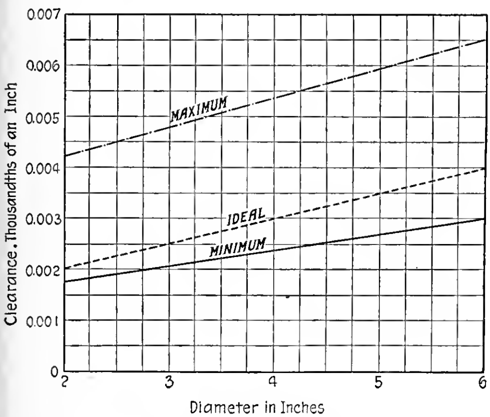
(3) The light load should be defined as 5 per cent. load.

(4) The permissible errors should be taken as 6 per cent. at 5 per cent. of full load and 2 per cent. at half and full load.

Allowances for Piston Fits*

By E. W. Weaver

The piston being the part first affected by the impulse of the explosion, friction at this point decreases the efficiency of the engine to a greater extent proportionately than at any point farther on. Therefore, it is of prime importance that its fit in the cylinder be the best obtainable and that it be sufficiently free to allow for the necessary oil film and for slight distortions under heat, yet close enough to prevent "piston slap."



Maximum, Ideal and Minimum Clearances

The problem is not like that of a solid plunger operating in a cylinder of heavy body and under such conditions as to insure an unchanging form and permit of copious lubrication. Instead, it is that of a comparatively delicate piston working in a cylinder with walls as thin as the designer dares make them and subject to extreme variations of temperature at different points.

The ideal allowance will be considered apart from that of manufacturing tolerances. Some engineers make the piston 0.001 in. small for each inch of diameter of the cylinder bore. The writer prefers to allow from 0.002 to 0.0025 in. for each inch of diameter above 2 in. This is shown in the chart.

As it is impossible to manufacture commercially parts that are all exactly alike, due allowance must be made for variations. The engine builder has the choice of three methods—(1) putting limits on the drawings and holding the inspection to such a point that any piston will work in any cylinder; (2) sorting and assembling the cylinders and pistons according to size; (3) making all the pistons a closer fit than they are expected to run at and lapping them to the proper fit, each in its own cylinder.

Only the first method, that of strictly interchangeable production, will be considered. The fixing of the limits to which the work is to be done is very important, as it directly affects the cost of the product. The drawing should represent what the engineer expects, what the shop will guarantee and what the company is willing to pay for.

Considering the cylinder first, a permissible variation between maximum and minimum size of 0.0015 in. is absolutely necessary—0.002 in. is the ordinary allowance—and the cylinder must not be tapered or "out of round" to exceed the given allowance. A variation of 0.001 in. between the maximum and minimum size for the piston is the usual allowance. If wider limits are given, more care must be exercised in assembling or the quality of the engine will be lowered.

As the head of the piston is exposed to the intense heat of the explosion, it must be made considerably smaller than the skirt. The amount is usually fixed at from 0.002 to 0.0025 in. smaller for each inch in diameter.

The fit of the piston ring in the groove is another important point. The ring must be loose enough to operate freely and close enough to prevent gas from leaking past. The minimum safe allowance is 0.0005 in., and the tolerances on both ring and groove must be given in such a way that this allowance is not diminished. The closest limit that is being worked to commercially is 0.0005 in. variation between the minimum and maximum of both ring and groove width. This would be expressed on the drawing as $\frac{\text{"}0.2500\text{"}}{0.2485}$ for the width of the groove and $\frac{\text{"}0.2490\text{"}}{0.2485}$ for the ring. Allowance must also be made between the ends of the piston ring for expansion under heat. From 0.006 to 0.015 in. is the usual amount.

The fit of the pin in the piston is the final point at which great care must be exercised, the proper allowance being 0.001 in. The hole in the piston, being reamed or broached, can be held from exact size to 0.0005 in. under size. In the case of a 1-in. piston pin, the hole in the piston would be dimensioned from 1.000 to 0.9995 in., while the pin would be given as 0.9990 to 0.9985 in., thus insuring a minimum allowance of 0.0005 in. and a maximum allowance of 0.0015 in.

It should be stated in conclusion that the suggestions in this paper apply particularly to water-cooled engines.

*From a paper presented at the annual meeting of the Society of Automobile Engineers, New York, Jan. 6 and 7.

Petroleum Developments

The world-wide activity in the search for petroleum deposits of commercial importance which characterized the year 1913 continued unabated during the early part of 1914. During the later part of the year, development in proved areas was greatly curtailed and exploration work postponed on account of the European war and the enormous overproduction of oil in the United States and Mexico.

The following paragraphs are from a statement by John D. Northrop, of the United States Geological Survey, discussing the petroleum developments in foreign countries in 1914, which has just been made public by the Survey.

NORTH AMERICA

CANADA—The productive fields of Ontario and New Brunswick continued to furnish the declining petroleum output of the Dominion. Though considerable effort was made to extend the boundaries of the productive areas, new production sufficient to offset the decline in older wells was obtained only in a few places. Good gas wells continue to be found in the Tilbury district, Ontario, but attempts to retard the declining oil output were unsuccessful.

MEXICO—Early in 1914 field operations in the oil districts of Mexico were very active—more so in the northern fields at Panuco and Topila than in the southern fields, where the work was interrupted by the belligerent political factions. The bringing in of an enormous gusher by the Corona Oil Co. (Dutch-Shell) at Panuco on Jan. 11 became the signal for a pronounced increase of work in the northern fields, where, as in the southern fields, the lack of adequate storage facilities tended to hamper developments greatly. Work in all districts was abruptly curtailed and in many places terminated in April. Late in the year the resumpton of local oil consumption by the Mexican railroads and mining industries served to revive activity to some extent.

Of more than passing interest was the fire which raged about the famous Potrero del Llano No. 4 well of the Mexican Eagle Oil Co., during the latter part of the year. Seepages of oil escaping to the surface after the well had been capped were ignited by lightning on Aug. 14, and up to the close of the year the fire, though confined to a small area, had defied all efforts to extinguish it.

SOUTH AMERICA

COLOMBIA—The discovery of petroleum and natural gas at Tubara, near the important Caribbean seaport of Barranquilla, indicates the development of an important oil field in close proximity to the Panama Canal.

BOLIVIA—Geologic investigations have shown the presence of a considerable area of prospective oil land south of Sucre, and the reported acquisition of petroleum concessions in that region indicates that the area will be thoroughly tested.

Relative Costs of Steam and Hydro-Electric Power

The question of relative efficiency and cost of installation and operation of hydro-electric and steam plants brought out some marked differences of opinion among experts at the recent hearings before the U. S. Senate committee while the Ferris water-power bill was under consideration.

Paul M. Lincoln, president of the American Institute of Electrical Engineers, advised that increased efficiency and lower unit cost of installation in the steam plant within recent years altered the hydro-electric situation materially, and that the value of potential water powers had perhaps been overrated because of failure to consider this fact.

"There is much public misconception," Mr. Lincoln declared, "as to the profits of hydro-electric companies, which are generally considered as very large because of the idea that water power costs nothing and the cost of operation is small, while the company's income is large." "On the contrary," he stated, "the interest, sinking-fund charges, taxes and depreciation on the larger initial cost of water-power installations are comparable with the cost of coal in a steam station. The invested capital in a water-power plant is so much greater than the public realizes that with interest charges at not more than 5 or 6 per cent., in a majority of cases from 70 to 80 per cent. of a water-power company's income is absorbed. This return to capital is not profit."

"When the cost of installation for water-power development amounts to $100 per kilowatt capacity against an installation cost of $50 per horsepower for steam," declared Mr. Lincoln, "it is always a serious question whether the steam plant is not likely to be more economical and profitable."

Several other electrical engineers testified along the same lines, urging the discrepancy between steam- and water-power installations and the growing efficiency in steam generation of power, to such an extent that advocates of the water-power bill intimated the possibility of an organized effort on the part of the electrical engineers and water-power companies to affect the pending legislation by depreciating the potential and actual value of water powers in the minds of the committee.

In support of his argument Mr. Lincoln said that engineers have claimed it would be cheaper to install a steam plant in St. Louis to furnish light and power in that city, than to transmit hydro-electric power from the Keokuk dam. An auxiliary steam plant, he claimed, could undoubtedly be installed in Buffalo to take the peak of the load for that city while the Niagara Falls Power Co. carried the main part of the load, and the combination would give Buffalo cheaper power than is now being furnished by the Niagara Falls company. In other words, the cost of the hydro-electric installation to carry a high peak is disproportionate to the return from this peak. He admitted, however, that, considering the entire load factor, the Niagara water power transmitted to Buffalo was developed cheaper than power could be generated there by steam. When questioned about Western power development and costs, he suggested that if water-power installation cost more than $150 per kilowatt capacity in Los Angeles, it would probably be found that steam power could compete with it.

Both O. C. Merrill, chief engineer of the Forest Service, and George O. Smith, director of the U. S. Geological Survey, attacked the statements of Mr. Lincoln and other engineers who testified along the same line. Mr. Merrill declared that Mr. Lincoln's statement that steam and hydro-electric production cost on the average about the same was startling, but wholly incorrect, and proceeded to quote figures from plants in operation. According to these figures the actual switchboard cost of power sold by the New York Edison Co. (Waterside No. 2 station) is approximately five mills per kilowatt-hour. This cost includes labor, fuel, supplies and repairs. On the basis of power generated, where 24.9 per cent. is lost in distribution, the Edison station cost is approximately four mills per kilowatt-hour. Fuel and labor costs of generation at steam plants in California were quoted as 0.336c. for Long Beach and 0.372 for Redondo, while the generation cost at the Pacific Gas & Electric Co.'s Borel hydro-electric plant was only 0.033c., or, with transmission cost added, 0.128 cent.

"On this basis," declared Mr. Merrill, "it would be as profitable to invest $380 per kilowatt capacity for installation at the Borel plant, considering the load factors in each instance, as to invest $50 per kilowatt capacity at the Long Beach steam plant; while the fact that this steam plant was being operated on a 20 per cent. load factor and the hydro-electric plant at 69 per cent. load factor, justified even a larger discrepancy in installation cost."

"In general," said Mr. Merrill," hydro-electric installation costing eight times as much as steam, instead of three times as much, might be considered economical and profitable."

Dr. Smith attacked the water-power engineers for having made much of the increased efficiency of steam production without having mentioned the equal increase in efficiency of hydro-electric production. Quoting from a report of Samuel Insull, president of the Commonwealth Edison Co., of Chicago, he showed that within the last ten years this company, with its steam plant, had quadrupled its investment and increased its output fifteen-fold. In 1903 a one-dollar investment in the Chicago plant yielded 3 kw.-hr., while in 1913 the one-dollar investment yielded 10 kw.-hr. Chicago, all steam, now shows a per capita consumption of a little over 300 kw.-hr. and an average income of a little more than 2c. per kw.-hr., while San Francisco, part steam and part hydro-electric, shows about the same average consumption, and an average income of a little less than 2c. per kw.-hr.

As compared with the showing of the Chicago steam plant of 10 kw.-hr. per dollar of investment, the San Francisco plant had shown 6 kw.-hr. to each dollar of investment in 1911, while the ratio for the Montana Power Co. (all hydro-electric), where the average consumption was as large as 1000 kw.-hr. per capita, was 15 kw.-hr. per dollar of investment.

Undeveloped Power in Eastern Rivers

The rivers of the northeastern and middle eastern portions of the United States are the best known in the country and the earliest in point of development, and their usefulness as sources of power and centers of industry has been demonstrated for several generations. Nevertheless, it has been shown by the work of the United States Geological Survey during past years and is demonstrated in one of the reports of the Survey that in spite of the long familiarity of manufacturers and industrial men in general with most of these rivers, the water resources they afford have not yet been appreciated and by no means developed to their fullest extent. In fact, there are very few rivers in this great region in which the development of water power has come anywhere near the maximum possible degree of usefulness.

The report mentioned, "Water-Supply Paper 261," contains records of flow during several years of the principal rivers in the section referred to, which empty into the Atlantic Ocean. In developing a water supply enormous sums of money may be uselessly expended unless observations of this kind are made throughout the various stages of stream flow.

Water Resources of Connecticut

The rapid industrial development of this state in recent years has given rise to numerous problems relating to water-supply. With an annual rainfall of 45 in. both surface and ground waters in Connecticut are large in amount, but the rainfall is sometimes deficient through periods of several weeks or months. Consequently, farmers must endure periods of drought, manufacturers must provide against fluctuating water power, and congested districts must arrange for adequate water-supplies. With increasing population conflicts of interest arise between water-power users and domestic consumers, and towns dependent on the same streams. With the development of irrigation and drainage another set of interests is making demands.

To meet the present situation and to provide for the future the first step in the solution of the water problem is a comprehensive study of the facts as regards both surface and underground supplies. How much available water is stored in the gravels and sands and bedrock of the state? How much does the amount fluctuate with the seasons? What is its quality? How may it best be recovered in large or small amounts? What is the expense of recovering it? How much water may the streams of the state be relied upon to supply? How much is polluted? How may the pollution be remedied? To what use should each of the various streams be devoted? What is the equitable distribution of ground and surface waters among the conflicting industries and communities?

Realizing the importance of such studies to Connecticut, the state joined forces with the Federal Government in order to carry on the work. In 1911 a coöperative agreement was entered into by the United States Geological Survey and the Connecticut Geological and Natural History Survey for the purpose of obtaining such information. The work in 1911-13 was done by A. J. Ellis and that in 1914 by H. S. Palmer, both of the United States Geological Survey.

The five areas first chosen for study represent more or less typical geologic conditions in different parts of the state.

Reports, including detailed maps, of the Hartford, Stamford, Salisbury, Willimantic, Saybrook, and Waterbury areas have been completed and will be published at the expense of the Federal Government, as water-supply papers for free distribution. Similar reports on the Pomperaug and Plainville areas are in preparation, and tentative plans contemplate covering the other towns in the same manner in order to obtain a detailed and authoritative inventory of the ground-water resources of the entire state.

Efficiency and Size of Steam Turbines

At a meeting of the West of Scotland Iron and Steel Institute, J. Golder, in a paper on "The Steam Turbine," said that as regards efficiency, the Elberfeld turbine in 1902 gave 62 per cent. A Chicago machine is guaranteed to give 74 per cent. A 35,000-kw. turbo set for New York is guaranteed to give 75 per cent. efficiency. As regards size of unit, so far as the turbine is concerned, there is room for still further increase, and 50,000-kw. sets are projected for the Greater London scheme; 10,000 kw. is getting quite common. A line of advance for which the turbine has long been waiting is the combination of high power with high speed. Ideal conditions for this are found in the case of the direct-coupled turbo-compressor, and some remarkable machines have been made.

For example, a Rateau turbine capable of 3000 hp. at 4000 r.p.m. has been installed in the Midlands. Generator makers, realizing the possibility of this compact and cheap prime mover, have risen to the occasion, and 3000-kw. at 3000 r.p.m. Rateau machines have been successfully installed. Fraser & Chalmers have built a mixed-pressure turbine nominally of 2000 kw. at 3000 r.p.m., but as this machine does its full load with low-pressure steam, it follows that the design is safe for a pure high-pressure turbine of about double that capacity. Continental builders are said to have made a 6000-kv.-a. set at 3000 r.p.m., and a 20,000-kw. set at 1000 r.p.m. The Chicago set of 25,000 kw. runs at 750 r.p.m. Rateau sets are under contemplation for an output of 15,000 kw. at 1500 r.p.m.

Public-Utility Legislation in Washington

Representatives of light and power companies have presented their arguments to the joint legislature of the State of Washington, favoring a bill which provides that a company desiring to found competing power plants must procure certificates of necessity from the public-service commission on a showing that the company already in the field is unable to furnish adequate service or is charging unreasonable rates. A further provision legalizes indeterminate franchises subject to public-utility commission authority as to rates and service, leaving plants subject to municipal purchase as going concerns by condemnation. Municipalities granting franchises retain jurisdiction over original construction of plants or systems. If the city and the company are unable to agree upon terms in thirty days, the public-service commission is empowered to grant the franchise. This power is also conferred upon the commission in disagreements where one company is serving two cities or desires to pass through one not served.

Representatives of the Stone & Webster Corp. addressed the body on the proposed bill and urged its adoption, which is practically assured. They stated that public service had reached a point where it was no longer possible to attract the capital needed for further development of power and light projects, due to the fact that many franchises are now entering upon the last year and the statutes give no security in renewals upon which to base future bond issues for extensions.

Another argument urged by the light and power men is that the state, through the public-service commission, has regulated their operation and fixed limitations of how much they may earn on such investments, but has provided no protection for the companies from irresponsible and ruinous competition. They ask the enactment of the pending law as a measure of protection to offset restrictions imposed by state regulation of rates and service.

Model Will Show How Rivers Are Measured

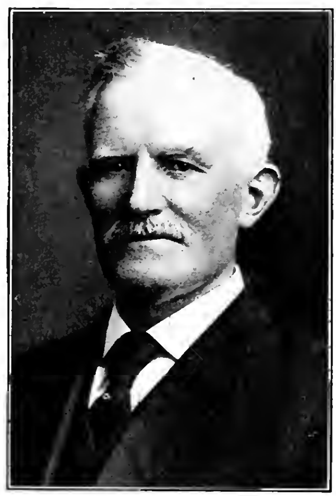
To show the way in which rivers are gaged—that is, how the volume of running streams is measured—by the United States Geological Survey, the exhibit maintained by the Survey at the Panama-Pacific Exposition, in San Francisco, will include a display of automatic gages, run by electricity, which record the fluctuating heights of water of an artificial river—one flowing through a tank.

The work of measuring the flow of the various streams of the United States every day in the year and some of them several times a day affords an invaluable basis for the study of our water resources. Upon the data thus obtained engineers depend in working out plans of water-power development, irrigation, drainage—in fact, every project in which running water is a factor.

OBITUARY

JOHN QUINN

John Quinn, efficiency engineer of the Mingo Steel Works & Furnaces, died on Saturday, Jan. 30, 1915. He was at his desk at the usual hour on Saturday morning, but complained of a sharp pain in the chest. He left the mill about 11 a.m. for his home, and passed away quietly at noon. He is survived by the widow, two sons (Robert S., master mechanic, and Herbert L., assistant master mechanic, Mingo Steel Works & Furnaces), and four daughters.



JOHN QUINN

Mr. Quinn was born in Ireland in 1850 and came to this country at the age of 20. He worked in a printing office in Cleveland for a short time and then entered the employ of the Newburgh Furnace, now the American Steel & Wire Co. He moved to Mingo Junction, Ohio, in 1882, as chief engineer of the Junction Iron & Steel Co., and upon the consolidation of the Laughlin Steel Co. and the Junction Iron Co. in 1884 he was made master mechanic, holding this position through the various changes made in this company until 1911, when he was made efficiency engineer.

He was a man of sterling character, high ideals and unquestioned ability in his chosen profession. His advice and counsel were eagerly sought, not only by the men in his employ, but by his superiors.

Mr. Quinn was actively interested in the religious, charitable, educational, industrial and financial life of the community, being president of the board of stewards of the M. E. Church, a member of the publishing committee of the Pittsburgh "Advocate," a member of the Ohio Valley Hospital Association, president of the Board of Education, efficiency engineer of the Carnegie Steel Co. and president of the First National Bank of Mingo Junction, Ohio.

In his long association with the Carnegie Steel Co. he made many friends among steel men and the allied industries, who will learn with regret of his sudden demise.

PERSONALS

Francis W. Hoadley, well known to mechanical engineers the country over from his long connection with administrative forces of the American Society of Mechanical Engineers, and since connected with the "Engineering Magazine," "Cassier's," and other publications, has accepted a position upon the staff of "Safety Engineering."

Clifton Reeves, head of the Reeves-Cubberly Engine Co., of Trenton, N. J., has been chosen by Secretary Wilson, of the Department of Labor, as a member of the Federal Board of Arbitration, for duty in the South. He has gone to Washington to receive further instructions and proceed to his appointed field. Mr. Reeves' appointment to this important board is the result of his interest and activities in labor matters. For 10 years he was secretary of the Employers' Association, during which time he assisted in the adjustment of several labor differences. He has resigned his position with the association, but will continue with the engine company.

B. F. Grout, consulting engineer, of Pittsburgh, Penn., and at one time professor in the School of Mines of the University of Minnesota, has recently been engaged by the Minneapolis General Electric Co. in connection with the tests of the efficiencies of its turbines in the Coon Rapids plant. Mr. Grout, in connection with his work at Massena, N. Y., investigated very fully what is known as the chemical method of measuring the volume of water flow. In this method a solution of salt is introduced into the penstock above the water wheels, and samples of the water issuing from the draft tube below give a measure of the quantity of water passing through the wheels. Mr. Grout, on Saturday, Jan. 30, gave a talk on the subject of these chemical tests before the Engineers' Club of Minneapolis, at a dinner held at the University Club.

ENGINEERING AFFAIRS

Louisiana Engineering Society—At the annual meeting of the Society held Jan. 9, 1915, in New Orleans, the following officers were elected to serve for the ensuing year: President, L. C. Datz; vice-president, Samuel Young; secretary, W. T. Hogg; treasurer, E. H. Coleman; director, Ole K. Olsen (to serve 3 years). The other members of the Board of Directors holding over are A. T. Dusenbury, W. B. Gregory and W. H. Williams.

Boiler Inspectors—At a recent meeting of the American Institute of Steam Boiler Inspectors of New York City, E. Haggerty was elected president; J. H. Pollard, secretary; and J. Turnbull, vice-president. The annual dinner will be held Feb. 20 at Rector's, Forty-eighth St. and Broadway. Prominent guests will attend, and with a star toastmaster in charge, it is promised that the dinner will eclipse any of the previous ones.

Equitable Dinner—In celebration of the completion of their part of the work on the new Equitable Building in New York City, about sixty mechanical and electrical material men gave a dinner to William Gordon, superintendent of mechanical and electrical equipment of the Thompson-Starrett Co., at the Hotel Claridge, Friday evening, Feb. 5. The committee of arrangements consisted of Paul H. Brangs, of the Heine Safety Boiler Co., who acted as toastmaster and George L. Gillon, vice-president of the National Metal Moldings Co., who was master of ceremonies.

International Engineering Congress—The technical success of the International Engineering Congress at San Francisco, Sept 20-25, is now well assured. From 200 to 250 papers and reports, covering all phases of engineering work, will be contributed by authors representing some eighteen different countries. The Congress will, therefore, be truly international in scope and character, although the representation from the warring countries will naturally be less than originally planned. The papers now rapidly coming in indicate that the proceedings will form an important collection of engineering data and a broad and detailed review of the progress of engineering art during the past decade. The Committee of Management is inviting all important engineering societies to send delegates, and the presence of a considerable body of them is well assured. Membership in the Congress, with the privilege of purchasing any or all of the volumes of the proceedings, is open to all interested in engineering work. For full particulars apply to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

BUSINESS ITEMS

The Terry Steam Turbine Co., Hartford, Conn., has appointed E. F. Scott representative for the State of Georgia, with offices at 702 Candler Bldg. The Pittsburgh office in charge of H. A. Rapelye is now located at 1624 Oliver Bldg.

The Terry Steam Turbine Co., Windsor St. at Windsor Ave., Hartford, Conn., is sending out a 64-page bulletin giving details on various turbo-pump applications. Anyone interested in any kind of pumping problem can have a copy for the asking.

The Builders Iron Foundry, Providence, R. I., has published a new bulletin—No. 142—which contains much interesting and valuable information on many important waterworks systems throughout the United States and Canada. It is sent free on request.

The Bruce Macbeth Engine Co., Cleveland, Ohio, has recently received orders for one 150-hp. natural gas engine from the Magnolia Petroleum Co., Fort Worth, Tex.; one 60-hp. artificial gas engine direct connected to generator, from the Ingersoll-Gaukler Co., Detroit; one 90-hp. natural gas engine from the Solar Electric Co., Brookville, Penn.; one 90-hp. natural gas engine from the Empire Marble Co., Cleveland; one 40-hp. natural gas engine direct connected to generator, from the Alhambra Theater, Sandusky, Ohio.

CONTRACTS TO BE LET

Bids received until Feb. 25, 1915.

Water Meters and Machinery

BUREAU OF ENGINEERING
DEPARTMENT OF PUBLIC WORKS.

Chicago, February 3, 1915.

Sealed proposals will be received by the City of Chicago until 11 a.m. Thursday, February 25th, 1915, at Room 406 City Hall, for manufacturing and delivering to the City of Chicago Water Meters, made according to designs prepared by the City of Chicago. The following quantities of water meters are desired:

1,500 ¾-inch meters.
2,000 1-inch meters.
750 1½-inch meters.
750 2-inch meters.

The city will furnish detail drawings and one set of patterns of each meter. The contractor is to turn over to the city upon completion of his contract special machinery, tools, dies, jigs, etc., used in the manufacture of the meters, according to plans and specifications on file in the office of the Department of Public Works of said city, Room 406 City Hall.

Proposals must be made out upon blanks furnished at said office, and be addressed to said department, indorsed "Proposals for Water Meters," and be accompanied with One Thousand Dollars in money or a certified check for the same amount on some responsible bank located and doing business in the City of Chicago, and made payable to the order of the Commissioner of Public Works.

The Commissioner of Public Works reserves the right to reject any or all bids.

No proposal will be considered unless the party offering it shall furnish evidence satisfactory to the Commissioner of Public Works of his ability, and that he has the necessary facilities, together with sufficient pecuniary resources, to fulfill the conditions of the contract and specifications provided such contract should be awarded to him.

Companies or firms bidding will give the individual names as well as the name of the firm with their address.

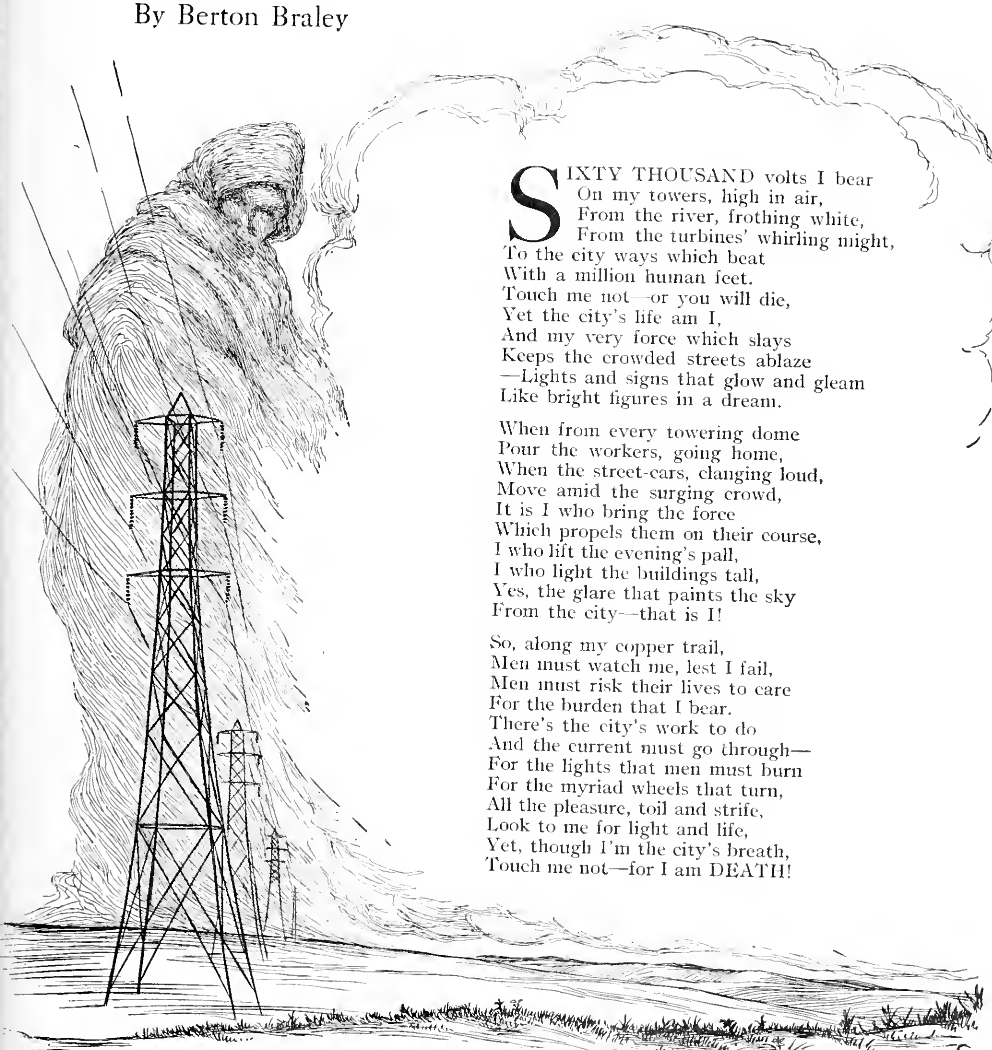
L. E. McGANN,
Commissioner of Public Works.

POWER

Vol. 41 NEW YORK, FEBRUARY 23, 1915 No. 8

The Transmission Line

By Berton Braley



SIXTY THOUSAND volts I bear
On my towers, high in air,
From the river, frothing white,
From the turbines' whirling might,
To the city ways which beat
With a million human feet.
Touch me not—or you will die,
Yet the city's life am I,
And my very force which slays
Keeps the crowded streets ablaze
—Lights and signs that glow and gleam
Like bright figures in a dream.

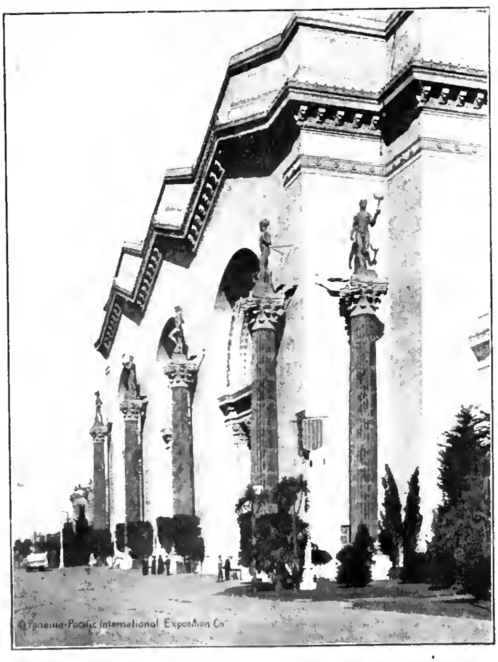
When from every towering dome
Pour the workers, going home,
When the street-cars, clanging loud,
Move amid the surging crowd,
It is I who bring the force
Which propels them on their course,
I who lift the evening's pall,
I who light the buildings tall,
Yes, the glare that paints the sky
From the city—that is I!

So, along my copper trail,
Men must watch me, lest I fail,
Men must risk their lives to care
For the burden that I bear.
There's the city's work to do
And the current must go through—
For the lights that men must burn
For the myriad wheels that turn,
All the pleasure, toil and strife,
Look to me for light and life,
Yet, though I'm the city's breath,
Touch me not—for I am DEATH!

The Panama Pacific International Exposition

Race Track, Aviation and Athletic Field State and Foreign Pavilions Education Food Products Agr
Drill Grounds Stock Exhibit Fine Arts Horticulture Libera

Third of its class held in the United States and twelfth of its class held anywhere in the world, the Panama-Pacific Exposition was officially opened when President Wilson touched the button last Saturday. Contrary to the usual international expositions, it is not the celebration of an anniversary of some past event, but commemorates a modern achievement—the completion of the Panama Canal. In its exhibits it is intended to show particularly the advance which has been made in the last ten years, or since the Louisiana Purchase Exposition. There being less of history in it than is usual, it is especially interesting to contrast some things contemporaneous with the years of the various World's Fairs. For example, in the steam-power field, we have, as typical of their respective times, the big Corliss walking-beam engine at the Centennial Exposition at Philadelphia in 1876 the quadruple-expansion 2000-hp. Corliss engine at the Columbian Exposition at Chicago in 1893, a 5000-hp. angle compound engine and a steam turbine of 2000 kw. at the Louisiana Purchase Exposition at St. Louis in 1904, with turbines as large as 5000 kw. built at that time, and now 35,000-kw. turbines, though none of that size will be exhibited at San Francisco, for the Panama-Pacific Exposition does not generate its own power for lighting and the operation of moving exhibits, but purchases its current from the Pacific Gas & Electric Co. which has over 90,000 kw. in hydro-electric installations and approximately 100,000 kw. in steam installations, the steam plants being boosters or auxiliaries in case of breakdown of the hydro-electric stations. Three-phase, 60-cycle, alternating current of 11,000 and 1000 volts will be furnished in amount up to 9000 kw. between 5 and 7:30 in the afternoon of any day or up to 15,000 kw. at any other time. The 18,000 kw. steam plant of the Sierra & San Francisco Power Co. is held in reserve, ready in case of interruption of the Pacific Gas & Electric service. The exposition's secondary distribution is at various voltages—117 for lighting, and 230 and 440 for power. Direct current by conversion through motor generators is available at 250-125 volts. The Centennial engine drove the machinery by means of lineshafts gear-driven from the engine and extending throughout the building.



Front End of the Palace of Machinery

The Centennial Engine

This engine was really a pair of beam-engines and formed the most prominent exhibit at the Centennial. They operated condensing and were supplied with steam at 80 lb. pressure. The valves and valve-gears were Corliss and the cylinders were 40 in. in diameter with 10-ft. stroke. The beams were 27 ft. long by 9 ft. deep and weighed 11 tons each. They were connected at right angles to a shaft carrying the flywheel, which was a cut gear wheel 30-ft. diameter and 2-ft. face, and was the heaviest cut wheel that had ever been made up to that time. It geared with a 10-ft. pinion on an underground shaft 256 ft. long running across the building. This lineshaft at each end and two intermediate points was connected by 6-ft. bevel gears to transverse shafts extending lengthwise of the building. These shafts were belted to eight overhead shafts, each 658 ft. long. The engine made 36 r.p.m., giving a piston speed of 720 ft. per min. The peripheral speed of the spur gears was 3384 ft. per min. The engines were rated at 1400 hp., but could develop 2000. The cylinders were jacketed with live steam.

San Francisco, California, Feb. 20 to Dec. 4, 1915

Tower of Jewels — Transportation — Manufactures — Varied Industries — Mines and Metallurgy — Festival Hall — Machinery — The "Zone" Amusement Concessions

Steam was supplied by twenty vertical boilers furnished by Corliss, which also supplemented the steam supply to the Pump Annex. Each boiler contained 48 tubes 3 in. in diameter in a shell 4 ft. in diameter by 14 ft. high. The total heating surface of the twenty boilers was given as 13,000 sq.ft.

Columbian Fair Engines

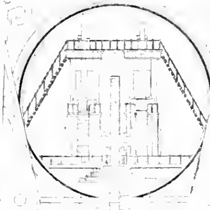
A heterogeneous collection of engines was to be seen at Chicago—horizontal and vertical, high-speed and low-speed—and no one type can be taken as representative of that time. The largest engine shown was a 2000-hp. Allis (Reynolds-Corliss) engine with 20-, 40-, 60- and 70x72-in. cylinders and 60 r.p.m. The flywheel was 30 ft. diameter by 76-in. face and carried two belts 6 ft. wide, each driving a Westinghouse 10,000-incandescent-light dynamo. Another notable engine was the 1250-hp. four-cylinder triple-expansion Buckeye engine with its distinctive valve-gear. Its cylinders were 20, 32 and 36x48 in. The flywheel was 20-ft. diameter by 72-in. face and it also

Vestibule to the Palace of Machinery

MACHINERY BUILDINGS
PHILADELPHIA 1876

POWER TRANSMISSION

Source: One 1400-hp. slow-speed Corliss engine in the center of one of the main bays.
Transmission by one main line of underfloor shafting, 352 ft. long and 8 overhead lengthwise shafts each 624 ft. long. The intermediate jackshafts were driven through 6 ft. bevel gears.

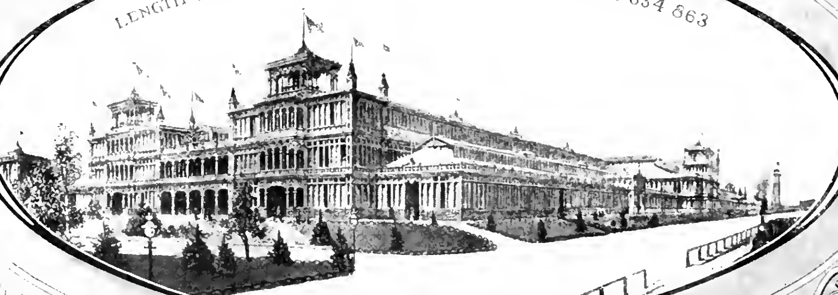


MATERIALS of CONSTRUCTION

STONE	15,000,000 Lb.
LUMBER	5,000,000 Bd. Ft.
WROUGHT IRON	760,000 Lb.
TIN ROOFING	700,000 Sq. Ft.
CAST IRON	500,000 Lb.
GLASS	175,000 Sq. Ft.
NAILS	20,000 Lb.

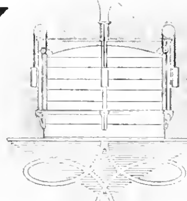
Constructed with brick curtain walls, square timber columns and wrought-iron roof trusses

LENGTH 1402 FT WIDTH 360 FT. AREA 13 ACRES COST $ 634 863

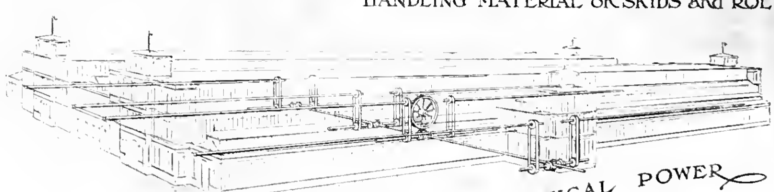


CENTENNIAL MACHINERY HALL

POST DETAILS and SHAFT HANGER



HANDLING MATERIAL on SKIDS and ROLLERS



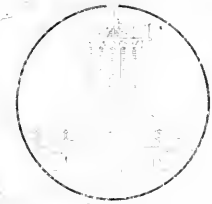
MECHANICAL POWER TRANSMISSION

AT TWO EXPOSITIONS
SAN FRANCISCO 1915

MATERIALS of CONSTRUCTION

PILES	45,000 Lin.Ft.
LUMBER	7,500,000 Bd.Ft.
BOLTS, WASHERS, Etc.	3,000,000 Lb.
COMPOSITION ROOFING	326,000 Sq.Ft.
GLASS	106,000 Sq.Ft.
NAILS	4 Carloads

Built entirely of wood, being the largest building of mill design ever constructed.



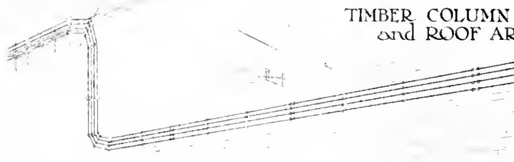
POWER DISTRIBUTION

Source: Two electric-power stations connected by distributing mains with all parts of the building. Total 20,000 Hp.
Power Circuits: Three-phase 60-cycle 250-volt and single-phase 60-cycle 117-volt.
Lighting Circuit: 60-cycle 117-volt three-wire system

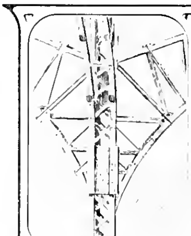
LENGTH 968 FT. WIDTH 368 FT. AREA 8.3 ACRES COST $650,000

PANAMA-PACIFIC PALACE of MACHINERY

HANDLING MATERIAL WITH OVERHEAD CRANE



ELECTRICAL POWER DISTRIBUTION



TIMBER COLUMN and ROOF ARCHES

drove through a 6-ft. belt. It has since developed that fewer cylinders and larger ratios are better and even triple-expansion engines are not warranted except with the higher pressures used in marine service.

Louisiana Purchase Exposition Engines and Turbines

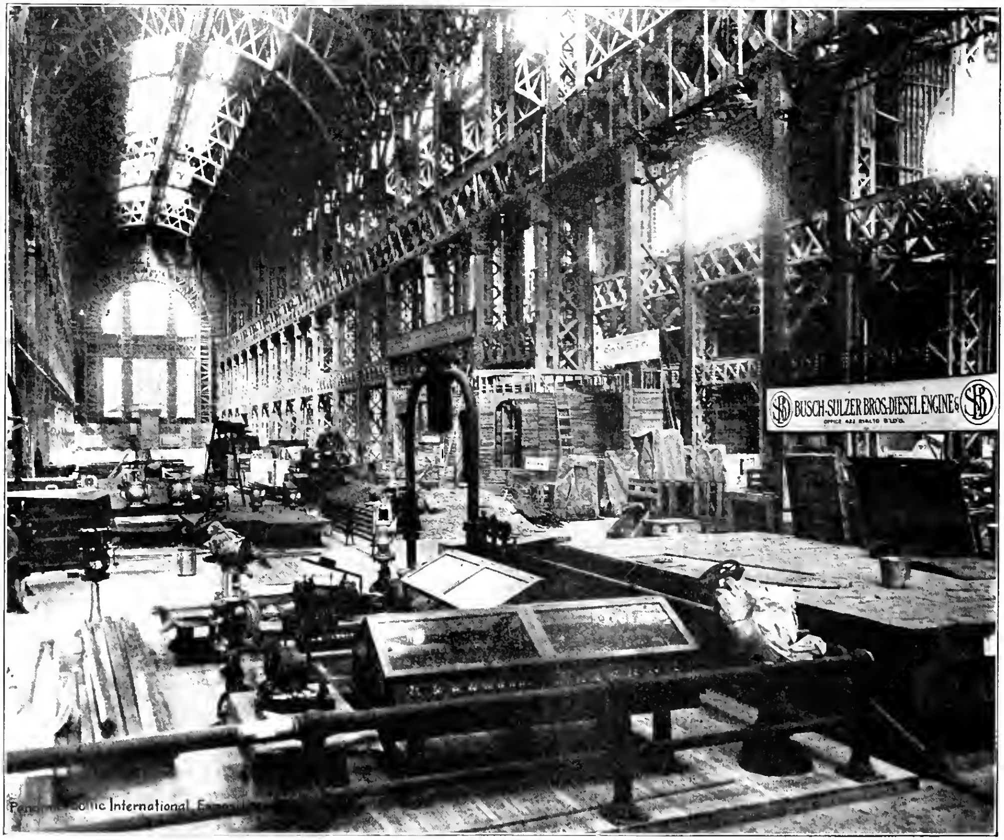
At this time (1904), the struggle between the turbine and the reciprocating engine was on and the advantage of the former, even in large units, was yet to be established. The largest turbines of their day were 5000-kw. Those exhibited were a 2000-kw. Curtis, a 1000-kw. Hamilton-Holzwarth, and a 400-kw. Westinghouse-Parsons. There were 21 engines, of which the 5000-hp. Allis-Chalmers angle compound was the largest, most impressive and most typical of the art and time. It had cylinders 44 and 94x60 in. and drove a Bullock generator by direct connection at 75 r.p.m. Four three-cylinder vertical compound 3000-hp. Westinghouse engines driving 2000-kw. generators were really not exhibits, but a part of the outfit bought by the Exposition.

Present-Day Prime Movers

At San Francisco, as the exhibits are not furnishing power for any considerable part of the exposition's needs, there was no occasion to install a prime mover of the size that must be taken as representative of this period for large capacity. Such a one, however, is the 35,000-kw. turbo-generator now being completed for the Philadelphia Electric Co. This unit, with its condensing equipment, will occupy a floor space of 1355 sq.ft., which is in marked contrast with the 2376 sq.ft. required for the Centennial engine. The horsepower output of the two units per square foot of area occupied is 34.6 for the new turbo-generator and 0.6 for the Centennial engine. The respective weights are 1,200,000 lb. and 1,400,000 lb., and the speeds 1200 and 36 r.p.m.

Centennial and Panama-Pacific Machinery Buildings Compared

The machinery buildings of the Centennial and Panama-Pacific expositions furnish a number of striking comparisons and contrasts as shown on the two accompanying pages. These give, by a few illustrations and tabulated data, a comparison of general dimensions and a few important features of these two great buildings. The Centennial Machinery Hall was a larger building, both in length and floor area, than the present Panama-Pacific Palace of Machinery. But this must not be looked upon as a step backward, for at Philadelphia the building de-



Inside the Machinery Palace during the Installation of Exhibits voted to machinery included everything that could be brought under that general head. In keeping with our present tendency toward specialization, the exhibits at San Francisco have been divided so that printing presses, typewriters, and similar machines now go to the Palace of Liberal Arts, while locomotives and all means of transportation have a building of their own.

One of the striking contrasts between the two buildings is in the materials of construction, for strange as it may seem, more metal was used in the Machinery Hall of Philadelphia 40 years ago than in the present Palace of Machinery in San Francisco. The two pages of illustrations give a hint as to the kind and quantity of these materials.

Another contrast worthy of mention lies in the provisions made for installing exhibits. In Philadelphia there was a total absence of crane service—not a single crane of any kind was used. At San Francisco there are two 30-ton cranes in the middle bay, with one 20-ton crane in each of the two principal side bays. The skids, rollers, and tackle of 1876 have given way to the traveling cranes of 1915.

General Features of the Present Fair

The grounds are in the city limits of San Francisco and face north on the bay. There are 2¾ miles of buildings, covering an area of 635 acres. While this area is only about half that occupied by the St. Louis Fair (1240 acres) and not even quite as much as the Chicago Fair (733 acres), this is an advantage rather than otherwise, for it means that the tiring distances to be walked are less. It cost more, however, than any exposition to date, for it represents an investment of $58,000,000, whereas the Louisiana Purchase Exposition cost $50,000,000, the Columbian Exposition $20,000,000 and the Centennial Exposition $8,000,000. For the present fair nothing was contributed by the Government as in the cases of the Chicago and St. Louis expositions. The palaces cost more than $12,000,000. Another distinguishing feature of this Fair is that the structures were finished three months before the opening, and it was the first international exposition to be considered completed on time.

White does not predominate in the buildings. The walls are of an ivory tint, and the roofs generally red and flat, with great domes and lofty towers of blue and gold, and green-latticed windows. Add to this the effect of the myriads of flowers, palms and trees, and it is evident that there is here no lack of color.

The tallest feature is the Tower of Jewels, 435 ft. high. On either side of it are the main exhibit palaces, 14 in number. Height in general marks these buildings as compared with the previous fairs, for the walls of the palaces are as high as the average six-story city block. Just east of the group is the amusement section known as "The Zone," to which there has been devoted 65 acres. To the west of the group are the pavilions of the 42 states and 38 foreign countries participating. In addition there are the parade grounds, live-stock pavilion, life-saving stations and the aviation and athletic field.

Eight exhibit palaces subdivided by courts make up the main group, seemingly under one roof and appropriately called "The Walled City." The buildings are in a rectangle, their walls being interconnected and broken only by archways and entrances giving access to the courts between the buildings. The buildings are all of the same height and the architecture generally similar. The courts dividing them north and south are known as the Court of the Universe, the East court, or the Court of Abundance, and the West court, or the Court of the Four Seasons. These eight central palaces are: Mines and Metallurgy, Transportation, Agriculture, Food Products, Varied Industries, Manufactures, Liberal Arts, and Education.

Palace of Machinery

Flanking this group on the east is the Palace of Machinery, in which centers the most of interest to Power readers and of whose exhibits more will be told in later issues. It cost approximately $650,000, and is the largest wooden building in the world. It was the first of the exposition palaces to be completed. Ground was broken on New Year's Day, 1913. The architecture is Roman, and the decoration is classic in form, but modern in expression and suggests machinery and invention. Inside, the building, is divided into three north and south aisles, each 101 ft. high and 75 ft. wide, extending the length of the building which is 967 ft. long. On each side of the main structure are side aisles 70 ft. wide covered with shed roofs 41 ft. high to the soffit of the trusses. The total width of the building is 367 ft. and the total floor space 370,000 sq.ft. In other words, it is about three blocks long, 8½ acres in size and as tall as a 13- or 14-story building. Lincoln Beachy, the aviator, flew from one end of it to the other under the roof. This was the first time an aëroplane flight was attempted indoors.

To facilitate the installation of heavy exhibits there are two 30-ton traveling cranes with 5-ton auxiliary hoists in the middle bay and a 20-ton traveling crane in each of the two principal side bays, all operating the length of the building. Railroad tracks enter and cross the building at the center at right angles to the crane travel, so that shipments received by rail can be unloaded from the cars directly by the cranes.

The first machinery exhibit was installed May 27, 1914, nine months before the opening of the Exposition. This was a Busch-Sulzer Diesel engine of 500 hp. The occasion was celebrated with fitting ceremonies attended by exposition, state and city officials and several hundred engineers. The exhibit is to be seen in one of the illustrations herewith.

Wherever possible, the exhibits are to be in operation, and many of them will also embody the exhibition of safety devices being arranged by William Doolittle, safety inspector of the National Metal Trades Association. To increase the convenience of viewing the building's exhibits electric chairs operating on tracks are provided, so that visitors may go from place to place by the pressing of a button and thus may spare themselves the fatigue which is such a drawback to exposition sight-seeing.

The sculptural feature of the Machinery Palace are three figures typifying the Triumvirate of Power, which are repeated in rotation at the tops of the 60-ft. columns flanking the entrances. These are called "Electric Power," "Inventive Power" and "Steam Power" and are the work of Haig Patigian, an Armenian by descent, but a resident of San Francisco. They are 16 ft. high and of a deep-golden color. Electric Power shows a man controlling a lightning bolt with his right hand, and dominating earth under his left foot. Inventive Power is symbolized by a heroic figure wearing the wreath of achievement and holding in his right hand a globe from which rises in flight a winged man. The power of steam is typified by a man in the act of creating motion with a driving rod of a steam engine attached to a crank which gradually blends with the earth.

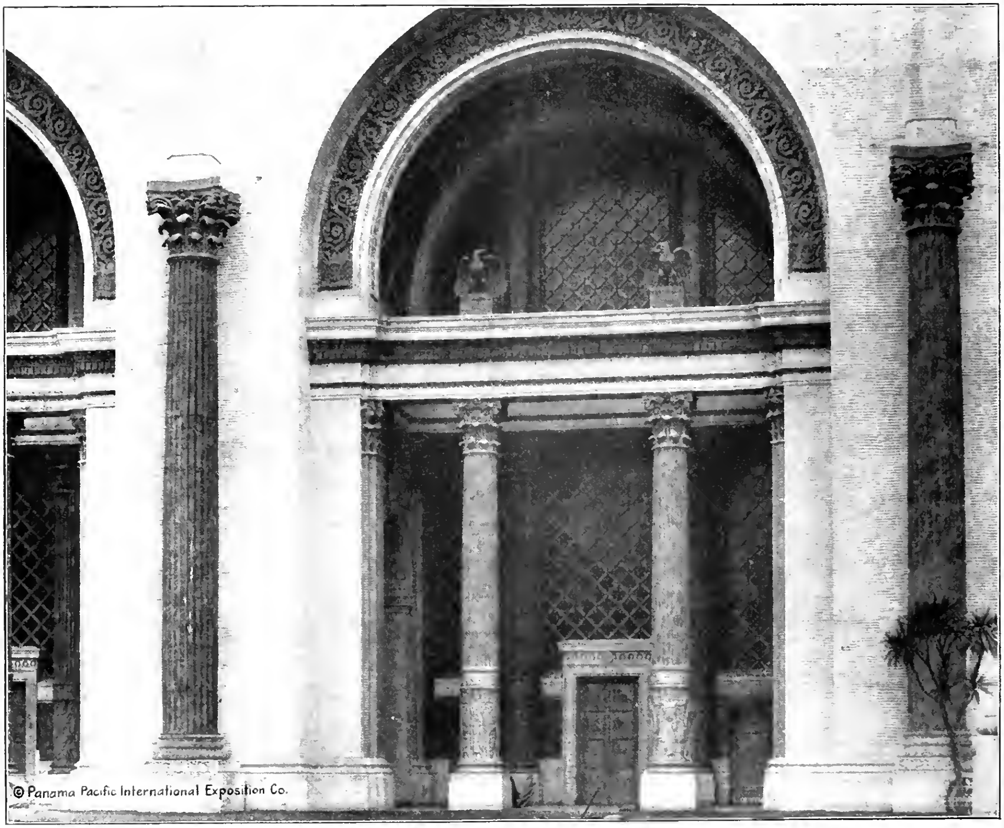
Other Buildings

Flanking the central group upon the west and separated from it by a lagoon, which it partly encircles, is the Palace of Fine Arts. The Palace of Horticulture covers approximately five acres and has as its most prominent feature a steel dome 186 ft. high and 153 ft. diameter, surmounted by a half-sphere 26 ft. high, weighing 26 tons. It is planted with flowers and at night is one of the most spectacular features of the illumination. Festival Hall will be the rendezvous of conventions, among them the Engineering Congress next fall. Nearly all of 350 congresses and conventions will be held here.

Methods of indirect lighting are used for out-of-door effects for the first time at any exposition. The palace walls are flooded by light from high-power arcs, concealed or shaded from the eyes of the spectators by ornamental metal shields or banners. Domes are illuminated from within by powerful searchlights arranged to give varying colored effects. Architectural features are accentuated by the use of "jewels" of polished crystal.

Of the nations which committed themselves to participate before the war, none has withdrawn. They include Argentina, Australia, Austria, Bolivia, Brazil, Canada, Chile, China, Costa Rica, Cuba, Denmark, Dominican Republic, Ecuador, France Guatemala, Haiti, Holland, Honduras, Italy, Japan, Liberia, Mexico, New Zealand, Nicaragua, Norway, Panama, Persia, Peru, Portugal, Salvador, Spain, Sweden, Turkey, Uruguay and Venezuela.

Visiting the Exposition has been facilitated as much as possible by the railroads and local hotels. Rates are being offered on all lines and the hotel men have formed an association, binding themselves to adhere to reasonable prices. In addition numerous boarding houses are available, so that accommodations within the means of all are claimed to be provided in abundance. Still, it is urged by the management that prospective visitors secure their reservations in advance to forestall any chance of disappointment in getting just what they desire.



One of the Three Main Portals of the Palace of Machinery

One of the most important features of the Exposition will be the series of congresses, conferences and conventions. As the material exhibits will show world progress on all lines, so will the congresses gather together the experience of the ages in education, science, art, industry and social service.

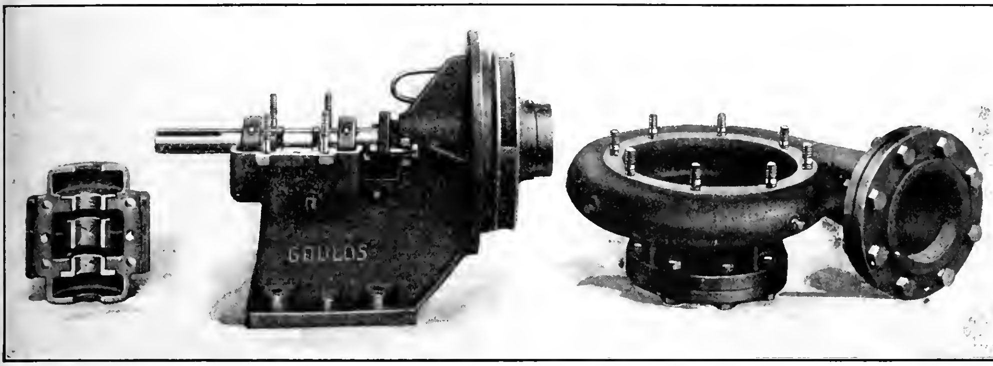
All in all, the Exposition holds attractions that cannot but make it worth while to any who can find the opportunity, to see it, and this aside from the advantages of viewing the country there and on the way.

Goulds Single-Stage Centrifugal Pump

The illustration shown herewith is that of the Goulds horizontal single-stage, single-suction, inclosed-impeller centrifugal pump with the casing and bearing cap removed. This pump is designed for directly connecting with electric motors, and is intended to run with different speeds for different capacities and heads.

bearing upon babbitted surfaces. These collars also serve to space the impeller properly in the casing. The waterway, or volute, is proportioned to convert the energy of the velocity of the water leaving the impeller into pressure, with a minimum of loss due to shock or eddies.

The casting forming the stuffing-box cover of the casing contains two bearings and carries the complete pump when assembled. The outboard end is split horizontally; the bearing cap is held in alignment with the bearing by



Centrifugal Pump with Casing and Bearing Cap Removed

The casing is of the volute type, supported on the bedplate so that it can be swiveled in any one of eight positions. This is a convenient feature where space for pipe fittings is limited, and also allows a discharge elbow to be dispensed with.

The impeller is of the inclosed type and is hydraulically balanced against end thrust. The slight amount of end thrust occurring in operation is taken up by shaft collars

the taper dowel pins and studs with locknuts. An opening with a hinged lid is provided in the top for inspection of the oil rings. Between the inboard end of the bearing and the face of the stuffing-box there is provided a drip pocket with a drain hole, which catches the necessary drip from the gland and is piped to a sewer.

This pump is manufactured by the Goulds Manufacturing Co., Seneca Falls, N. Y.

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., in looking on while a hydrostatic test is applied to a boiler, sees a demonstration of how the spoils system usually works out. Will, however, derives some benefit from his experience by consulting Chief Teller.

"While away on my vacation, Chief, I found time to peep into some of the boiler rooms in my home town; it has a boiler-inspection law. The inspector is in reality appointed by the mayor and the civil-service part is framed up afterward.

"While the members of the local examining board know nothing about boilers and engines, they are supposed to know how to judge and certify as to the fitness of the candidate after the mayor has appointed him.

"I happened to be chatting with John Starch, who fires at the laundry, when the boiler inspector came in. His method of applying a hydraulic test to the idle boiler puzzled me. The boiler is supposed to be good for 100 lb. and the inspector said he was going to test it for 50 per cent. over-pressure. I watched the gage and he ran the water pressure up to 200 lb., when the shell leaked like a sieve. One of us has this percentage business twisted. What is a 50 per cent. over-pressure, Chief, and how do you figure it? I want to know which of us was wrong."

"I am glad you got some practical information during your vacation, Will, by seeing how other plants are operated. Per cent. means 'by the hundred.' Your problem is easily illustrated by our decimal money: A dollar is 100 cents, and one penny or centum is therefore 1 per cent. A dime is ten one-hundredths, or 10 per cent., and half a dollar is 50 per cent. One hundred represents the base and 50 per cent. added would, of course, be a total of 150.

"You say the boiler is intended for 100 lb. steam pressure, and that it was to be tested to 50 per cent. over-pressure. Fifty per cent. of 100 lb. is 50 lb. Then the total test pressure should be

$$100 + 50 = 150 \textit{ lb.}$$

By putting on 200 lb., or doubling the working pressure, the inspector added 100 per cent., incidentally showing an extremely low percentage in his knowledge of percentage."

Spark-Plug Ignition Systems

By Albert H. Israll

SYNOPSIS—Explanation of the induction coil and magneto, as well as the operation of the common systems of spark-plug ignition.

Simple Induction Coil

The air gap across which is sent the ignition current offers a very high resistance to its passage. For this reason a current of low voltage from a battery or a low-tension magneto is unable to jump the gap. To transform this low-potential current to one of very high potential, amounting to many thousand volts, a device known as the induction coil is employed.

In its simplest form, the induction coil is composed of several layers of coarse wire (the primary) wound around a core of soft-iron wire and surrounded by many layers of fine wire (the secondary). The core tends to concentrate the lines of force and becomes an electromagnet when the coil is in use. In Fig. 1 is shown such a coil, with only one layer of each winding, for simplicity.

When a current is sent through the primary a magnetic field is set up around it, the lines of which pass through the core parallel to the axis, coming out at one end and entering at the other after passing through the layers of the secondary winding. A current is thereby induced in the secondary, the potential of which depends on the relative number of primary and secondary turns. When the current through the primary has reached a constant value, the induced current in the secondary ceases to flow. The magnetic field set up by the primary also tends to retard the current flowing through it, so that it takes longer for the field to build up from zero to maximum than to drop from the maximum to no field when the flow of current ceases. The voltage of the current generated in the secondary winding depends also upon the rapidity with which the intensity of the magnetic field changes. For this reason the current generated in the secondary is of much higher potential when the circuit through the primary is broken than when closed.

No current can be induced or generated in the secondary winding unless the intensity of the magnetic field is either increasing or decreasing. Thus there are two impulses of current in the secondary, one when the primary circuit is closed and the other when it is opened; but, as previously stated, the current induced at the break of the circuit is the only one of sufficient voltage to be utilized.

Induction Coil with Vibrator

The simple coil just described is used in a system explained later, where the make-and-break occurs once for each explosion and where only one spark is produced. There are systems, however, in which a series of short sparks are produced for each ignition. These add a small mechanism to the simple coil, called a vibrator (see Fig. 2). A current sent through the primary produces a magnetic field, making the core an electromagnet. The tension of the spring tends to keep the two platinum points together, thereby keeping the primary circuit closed; but when the core becomes magnetized it exerts enough force to attract the spring and open the circuit rapidly. As soon as the circuit is opened the core becomes demagnetized and the spring flies back, again closing the circuit. This making and breaking of the circuit by the vibrator occurs at the rate of about one hundred per second, depending on the adjustment. Each time the primary circuit is broken a small current of high potential induced in the secondary jumps the air gap of the spark plug.

As previously stated, a current is also induced in the primary winding each time the circuit is broken, and unless a condenser is employed to take up this current, considerable arcing will occur at the two platinum points, preventing a rapid break of the primary circuit and burning away the points in a short time.

The condenser consists of layers of tinfoil separated from each other by a waxed- or varnished-paper insulation. No connection is made between the two sides of the condenser within itself. The action is such that the current generated in the primary winding when the circuit is broken is absorbed by the condenser, but as soon as this induced current ceases to flow the condenser discharges again. The discharge current, however, flows back through the primary in the opposite direction to that of the battery current, thereby quickly demagnetizing the core. Therefore, the condenser not only does away with the undesirable sparking at the points, but also lessens the

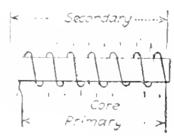


Fig. 1. Simple Induction Coil

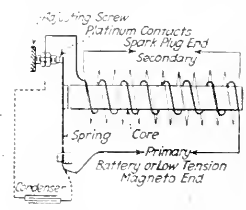


Fig. 2. Coil with Vibrator and Condenser

resistance to the flow of the battery current. It is generally inclosed in the box containing the coil.

Since the secondary current is of very high potential, there would be danger of the insulation being punctured if the circuit through this winding could not be completed. This might happen if a wire had been disconnected from a spark plug, if one of the secondary leads were broken, or if the ground connection became loose or had been left off. Therefore, to prevent the destruction of the coil from these causes, a safety spark gap is inserted in the system of each induction coil and high-tension magneto. The distance between the two points is greater in the safety gap than in the spark plug, hence the current will always jump the gap in the spark plug, except under the conditions mentioned.

The Magneto

In the induction coil just described the secondary wires remained stationary, while the lines of the electromagnetic field cut them as the intensity of the field was varied. If instead a stationary magnetic field be employed and the wires be moved through it, a similar result would be obtained. This is the principle employed in the magneto, the essential parts of which are the permanent magnets producing the magnetic field, the pole-pieces through which the magnetic lines of force pass before crossing the path of the armature, and the armature which consists of a core and windings. The core is generally of the shuttle type and the windings depend on the type of magneto; if low tension, the windings consist merely of heavy wire.

The current generated is not constant during one revolution of the armature, but whenever the armature winding passes through the strongest portion of the field, the maximum current is generated: this happens twice during each revolution. To obtain the best spark the maximum current must be utilized, and to do this the mechanism must be constructed so as to make this adjustment possible. The interrupter is generally on the same shaft as the armature, but the distributor arm is on a shaft placed above the armature shaft and is geared to the latter. The armature shaft and distributor shaft are so geared that when the interrupter acts to produce a spark the distributor arm will be in contact with or over one of the segments. To make clear the relation between the speeds of the shafts, assume a four-cylinder four-stroke-cycle engine. Two explosions occur per revolution of the crankshaft and, since two breaks occur at the interrupter points per revolution of the armature shaft, the speed of the two will be the same. There will be four segments, one for each cylinder, to distribute the high-tension current; thus the distributor shaft will make one-half a revolution for each one of the armature shaft.

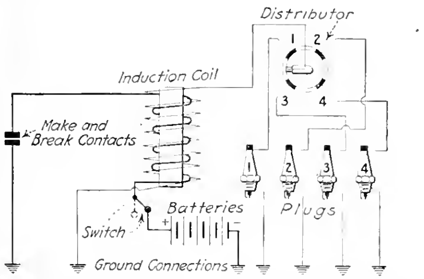


Fig. 3. Make-and-Break with Simple Coil and Spark Plugs

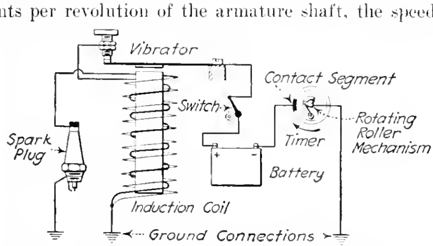


Fig. 4. Vibrator Induction Coil (Single Coil)

Difference between High-Tension and Low-Tension Magnetos

The chief difference between a low-tension and a high-tension magneto is that the latter is self-contained and very compact, while the former requires a separate induction coil. The high-tension magneto has wound on its armature, in addition to the layers of heavy wire, many layers of light wire which serve as a secondary winding. Instead of using a separate coil the armature serves both as a generator and as an induction coil.

The diagrams showing the different systems have been drawn to show the wiring and not the constructional details; therefore, the interrupter has not been shown on the shaft with the armature. Another thing to note is that the safety spark gap and the condenser have been omitted to prevent confusion.

Simple Coil (Make-and-Break)

When ordinary spark plugs are employed the make-and-break points are outside the cylinder. There are two systems in general use, one in which there is a long make and a second in which there is a very short make. The mechanism is so timed that it is mechanically operated whenever the spark is to occur. The break in the latter system occurs so quickly after the make that the eye cannot detect the two points in contact at all. The fundamental principle of operation is the same, however, in both (see Fig. 3).

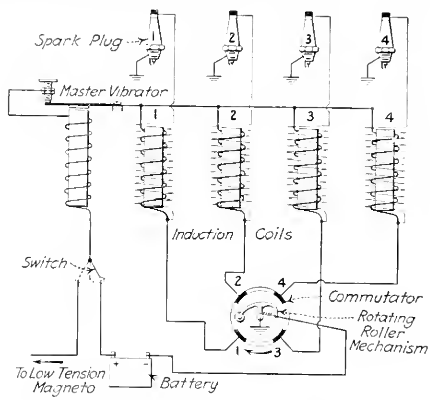


Fig. 5. Vibrator Induction Coil (Multiple Coil)

The current passes from the positive terminal of the battery through the primary winding when the points are in contact. This produces a strong magnetic field in the coil, and when it is allowed to shrink suddenly on the opening of the circuit, a current of high voltage is induced in the secondary. The latter flows through the distributor and jumps the gap in the spark plug, completing its circuit by way of the ground.

Vibrator Induction Coil (Single Coil)

In this system, which is shown in Fig. 4, a single induction coil is used. When the timer or commutator closes the primary circuit, which occurs when the roller is in contact with the segment, a current flows from the positive terminal of the battery through the vibrator, the primary winding, the ground and the roller to the negative terminal of the battery, thus completing the circuit. Each time the circuit is broken by the vibrator, a high-tension current is induced in the secondary, which jumps the spark gap of the spark plug. The spark produced at the gap is not merely one, but a series of sparks which succeed each other so rapidly that they appear continuous.

It should, of course, be understood that the roller mechanism of the timer is connected by shafts and gears to the crankshaft, so that there is a definite relation between the speeds of the two, and the spark is made to occur at a definite time.

Vibrator Induction Coil (Multiple Coil)

The wiring of this system (see Fig. 5) is so arranged that whenever a current passes through any of the induction coils, it must first pass through the master vibrator which is in series with each coil. This saves the use of a number of vibrators and gives a spark of the same intensity in all cylinders. Assume that the roller mechanism is rotating in the direction indicated by the arrow. When it touches segment No. 2, the circuit through the primary is closed, provided that the switch is on. The current then passes from the positive terminal of the battery, through the winding of the master vibrator, coil No. 2, segment 2 and back to the battery, causing the vibrator to act as before explained. Each time the circuit is closed

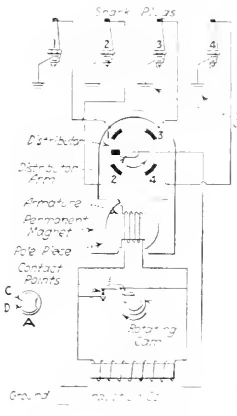


Fig. 6. Low-Tension Magneto

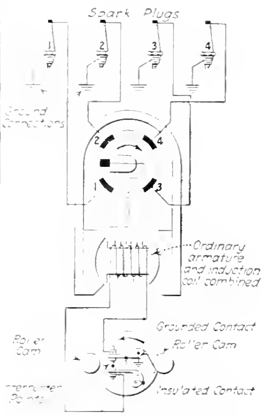


Fig. 7. High-Tension Magneto

and broken by the vibrator a magnetic field appears and disappears in the induction coil No. 2, and sets up a secondary current of high potential, which current jumps the air gap of No. 2 plug. The primary wire from each of the induction coils to the commutator also serves to ground the secondary wire on the respective coils, thereby eliminating four wires. In following out the circuits it should be noted that the roller mechanism is connected to ground.

Low-Tension Magneto

The system shown in Fig. 6 will operate in either of two ways, depending on the design of the rotating cam which operates the interrupter mechanism. With the cam as shown the system works as follows: The current generated in the armature of the magneto passes through the primary of the induction coil, except when the points of the contact-breaker come together. It is so arranged that the points come together while the maximum current is being generated in the armature. At this instant the major portion of the current passes through the interrupter. The sudden decrease in current flowing through the primary of the coil causes a rapid shrinkage of the field, which, in turn, induces a small current of high voltage in the secondary winding; this passes through the distributor, across the air gap in the plug and through the ground, completing its circuit.

When the cam shown at *A* is used the points of the interrupter are always in contact except during a short period preceding the production of the spark. The current from the armature of the magneto passes through the interrupter until the point *C* of the cam reaches the breaker arm. At this instant the points separate and the whole current is forced to pass through the primary winding of the induction coil. Although this induces a current in the secondary winding, it is not of sufficient potential to jump the spark gap. While the maximum current is being generated in the armature, the point *D* on the cam strikes the breaker arm and the contact points are instantly brought together again. The larger part of the current now flows through the interrupter again and the rapid decrease in the current passing through the primary winding causes a sudden shrinkage of the magnetic field. This induces a current in the secondary of sufficient tension to jump the spark gap.

High-Tension Magneto

The system shown in Fig. 7 is often called the true high-tension magneto system. The breaker or interrupter mechanism is on the shaft carrying the armature and rotates with it. The roller cams, on the other hand, may rotate on pinions whose positions remain fixed.

In the position shown, the grounded contact arm is about to be pushed inward by the roller cam; thus the interrupter points are about to separate. The armature is short-circuited through the interrupter points except when the spark is to occur. The mechanism is so timed that this takes place when the maximum current is being generated. When a spark is to occur the points are separated and the primary circuit is opened. The current immediately ceases to flow through this winding, causing the field to shrink very rapidly. This, in turn, induces a small current of high potential in the secondary winding on the armature, which passes through the distributor, jumps the spark-plug gap and completes its circuit through the ground.

Dual System

In this there are two distinct ignition systems which are generally not connected in any way, two sets of spark plugs often being employed. It is a combination of the systems shown in Figs. 5 and 7, namely, the vibrator induction coil and the high-tension magneto.

Duplex System

This system is the outcome of an improvement on the one shown in Fig. 7. The high-tension magneto is so designed that the armature may be used not only as an induction coil for the current generated in itself, but also for the current from a battery. Thus only the battery is added, but the wiring becomes more complex. An advantage is that without separate induction coils the engine may be started on battery current, which is generally easier than with the current from the magneto. This is due to the fact that the engine must attain considerable speed before the voltage of the current generated in the magneto becomes equal to that of the battery, namely, six to seven volts.

New Schlotter Blower

By Alfred Gradenwitz

A new type of blower has been brought out by Messrs. Siemens-Schukert Werke, of Berlin, Germany. Like all blowing machines of the screw type, the Schlotter blower, Fig. 1, requires but small floor area, is high-speed and

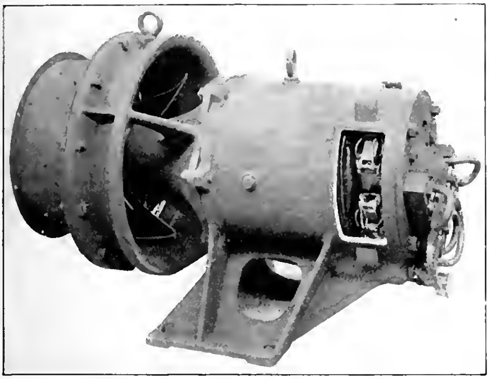


Fig. 1. Schlotter Blower, Motor Driven

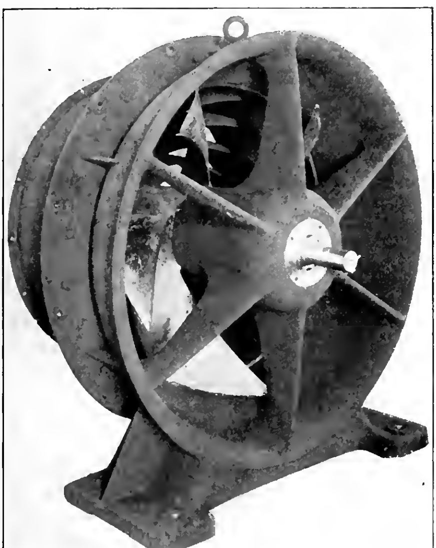


Fig. 2. Rotor and Casing

is reversible. Back pressures up to 11.5-in. water column are overcome by a single-stage blower, the maximum efficiency being upward of 80 per cent.

Each blower comprises a 5-vane rotor, Fig. 2, and a guide wheel, Fig. 3, at the outlet. The thrust surfaces of both wheels are of the screw type, that is, surfaces engendered by the rotation of a line and its simultaneous displacement along the axis of rotation. The feature of the guide-wheel principle is that the entrance edges of the guide wheel, so far from coinciding with the outlet edges of the rotor cross them at right angles everywhere. The air current issuing from the rotor is thus subdivided radially by each guide blade and is, at a given air supply, dealt with without a shock.

The curvature of the guide blades, which increases in the direction of rotation of the rotor, results in a con-

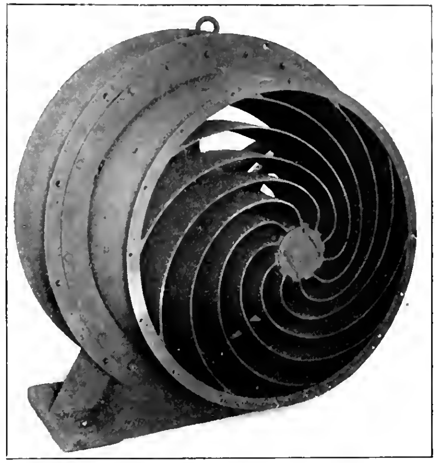


Fig. 3. Guide Wheel of Blower

traction of the air current and in a further acceleration of the resting guide wheel, so that a considerable portion of the axial thrust is engendered in the latter. Because of the inertia, the air currents on issuing are slightly rotating and convergent to the axis, so that the minimum cross-section of the jet in the case of a free motion of the air lies at about half the length of the diameter in front of the distributor.

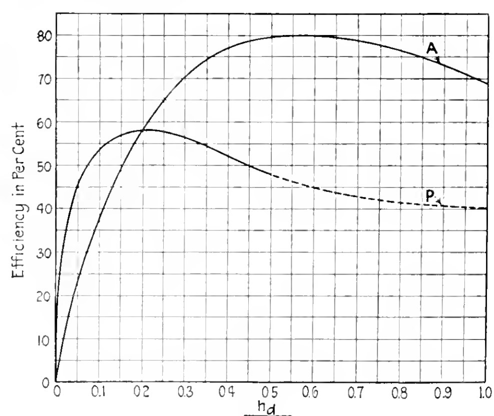


Fig. 4. Efficiency Curves of Schlotter and Centrifugal Fan of Usual Design

The efficiency of a blower depends mainly on the extent to which dynamic pressure in the adjoining tubings can be converted into static pressure. Tests have shown a maximum efficiency of about 80 per cent. to be obtainable in the most favorable case, when connecting the blower to a line of pressure pipes, and 75 per cent. can be reached with a short outlet tubing corresponding to an increase on cross-section of about 20 per cent., the efficiency decreasing in the case of a diffuser, according to the widening of the latter. These results have been confirmed by tests made on a number of middle-sized blowers, chosen at random, by Professors Brabbee and Kloss, of the Berlin Technical High School, the maximum efficiency found with a pressure pipe connected to the blower being 78 per cent.

An even more important factor than the high maximum efficiency is the fact that the efficiency curve of the Schlotter blower is flat, so that the efficiency remains high over a wide range of loads, from the highest back pressure down to a free escape. In Fig. 4, curve *A* shows the efficiency curve of a Schlotter blower as compared with that of a centrifugal fan of the usual design, as shown in the curve *P*.

Another advantage of the blower is that its power consumption for a given number of revolutions remains constant over practically the whole range of loads. This is valuable in case the back pressure of an installation cannot be predetermined exactly or when working conditions, with a given amount of air, entail variations in back pressure, such as, for instance, with the individual ventilating of mines, when using air pipes of variable lengths.

The annular cast-iron body of the blower is provided with a foot and comprises in its hollow hub the bearings carrying the shaft on the journal of which the rotor and the half coupling (belt pulley) are keyed overhung. Ball bearings are used. Water cooling is provided for the bearings when the blower is used with hot gases.

The standard design is modified in various ways to suit special requirements. The annular body may be fitted with a flange in the place of the foot, in case the blower is to be fixed to a wall. Since every blower is fitted with a thrust bearing to deal with the axial thrust, there is no objection to placing it in a vertical position. When the blower is to work through a conduit, a suction bend is joined to the annular body through which the driving shaft passes.

The rotors are cast either of some light metal (special aluminum alloy) or a high-grade bronze, according to their dimensions and numbers of turns and the gas temperature.

The blower is preferably driven through direct coupling with electric motors, steam, water or air turbines. The most important applications of the blower are for ventilators for boiler and engine rooms; for the individual and main ventilation of mines and tunnels; for air heating, drying and mist-dispelling plants; for forced-draft furnaces and for the removal of dust and shavings.

Designing Small Transformers

By Norman G. Meade

SYNOPSIS—Actual calculations in the design of a small transformer such as used for bell circuits or signaling devices.

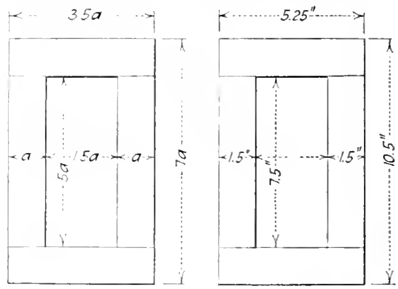
Small transformers with low-voltage secondaries are, to a large extent, replacing batteries for many purposes, such as the operation of electric bells, signaling devices, etc.; and where alternating current is available they are much more satisfactory, as they require no attention. As the secondary voltage is generally below 12 or 15 volts, ordinary bell wiring is sufficiently insulated for the secondary circuits.

The design of the small transformer involves the same calculations as transformers for lighting and power purposes. It is necessary to know or assume several quantities, such as the useful secondary output in kilowatts, the primary voltage, secondary voltage, and the frequency of the system on which the transformer is to operate. Let it be desired to design a transformer to operate from a 110-volt, 60-cycle circuit, which will have a secondary voltage of 10 and a secondary current of 10 amp.

$$Efficiency = \frac{watts\ output}{watts\ input}$$

For an output of 100 watts, assuming an efficiency of 85 per cent.,* the input would be $100 \div 0.85 = 118$ watts. Therefore, the total estimated losses are not to exceed 18 watts. These losses are made up of three components—hysteresis, eddy currents and copper losses. The copper or I^2R loss and the core loss (hysteresis and eddy currents) should be about equal. For intermittent service the copper loss can be somewhat the larger of the two; hence it will be taken as 10 watts and the core loss 8 watts.

Assume the density of the sheet-iron core to be 30,000 lines of force per square inch. For annealed sheet iron at this density, the hysteresis loss is 0.15 watt per cubic inch. The eddy-current loss should be small on account



Figs. 1 and 2. Core Dimensions

of the laminated core; therefore assume it to be 2 watts and the hysteresis loss 6 watts. The volume of the iron in the core will then be

$$\frac{6}{0.15} = 40\ cu.in.$$

The core must be proportionate with regard to the winding space and the length of the magnetic circuit. Let a represent the width of the core, as in Fig. 1, $7a$ the height of the core, $3.5a$ the total width, $1.5a$ the horizon-

*This efficiency is somewhat lower than would be obtained in a well designed transformer of this size under full load.—EDITOR tal inside distance between legs, and $5a$ the distance between the yokes. The cross-section of the core is a^2. Then the volume of the core is

$$V = (2 \times 3.5a + 2 \times 5a)a^2$$

or

$$V = 17a^3 = 40 \text{ cu.in.}$$

Whence, $a = \sqrt[3]{\frac{40}{17}} = 1.34$, approximately.

Let a be 1.5, on account of some loss of space due to laminations. Then the core dimensions will be as shown in Fig. 2 and the available winding space will be 2.25 in. between cores and 7.5 in. between yokes. Let the length of coil be 7 in. The secondary will be wound next to the cores so as to reduce the length of the heavier wire, and the primary will be wound over the secondary. The secondary current at full load will be 10 amp., and, as the primary and the secondary coils are wound in two sections, the secondary voltage for each coil will be 5 volts, but the conductor will carry 10 amp. Allow 1000 circ.mils per ampere. Then the size of the secondary conductor will be 10 × 1000 = 10,000 circ.mils, which corresponds nearest to a No. 10 wire.

The primary watts at full load are 118; hence the primary current will be

$$\frac{\textit{Primary watts}}{\textit{Primary voltage}} = \frac{118}{110} = 1.07 \textit{ amp.}$$

The power factor can be neglected and, as the magnetizing current is small, the primary current will be taken at 1.25 amp. The size of the primary wire will then be

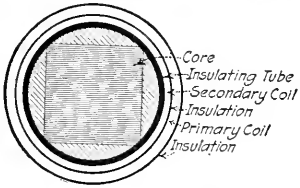


FIG. 3. SECTION THROUGH CORE AND COIL

1.25 × 1000 = 1250 circ.mils, which corresponds nearly with a No. 19 wire.

The relation between the maximum flux and the effective primary voltage is as follows:

$$V_p = \frac{4.44 N \times T_p \times n}{10^8}$$

where,

V_p = Primary voltage;
N = Maximum magnetic flux;
T_p = Primary turns;
n = Frequency.

The maximum magnetic flux equals the flux density, in the present case 30,000 lines per square inch, times the cross-section of the core in square inches; that is,

$$N = 30{,}000 \times 2.25 = 67{,}500 \textit{ lines.}$$

Substituting in the above formula,

$$110 = \frac{4.44 \times 67{,}500 \times T_p \times 60}{10^8}, \text{ and}$$

$$T_p = \frac{110 \times 10^8}{4.44 \times 67{,}500 \times 60} = 611 \text{ (approximately)}$$

To arrive at even numbers make the total primary turns 612, or 306 turns on each core. The number of secondary turns will be

$$\frac{\textit{Secondary voltage}}{\textit{Primary voltage}} \times T_p = \frac{10}{110} \times 612 = 56$$

or 28 turns to the coil. The arrangement of the windings on the core is shown in Fig. 3. The corners of the core are slightly rounded and it has four segmental blocks of hardwood on four sides. The wood should be well filled with shellac or insulating paint. The inside diameter d of the secondary coil figures 2.12 in., as illustrated in Fig. 4; but as the corners of the core are rounded, the inside diameter will be taken as 2 in.

From a magnet wire table it will be found that No. 10 wire has 8.54 turns to the inch and, as the length of the coils is 7 in., there is twice the space needed for the secondary winding of 28 turns per coil. Therefore, it will be

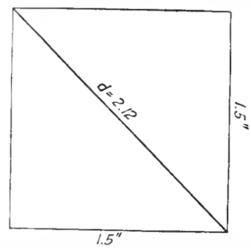


FIG. 4. ILLUSTRATING METHOD OF DETERMINING INSIDE DIAMETER OF SECONDARY COIL

necessary to wind a cord the diameter of the wire parallel with it, to make a good job. The secondary winding should be wound on a stiff insulating tube of the required diameter; a piece of mailing tube will do. Before winding, the tube should be thoroughly impregnated with insulating compound. For winding, the tube should be slipped on a wooden arbor and placed in a lathe. When the winding is in place the ends should be secured with cord and wrapped with two or three thicknesses of oiled cloth, then wrapped with webbing and painted or shellacked. The ends of the winding should be cut off about an inch from the core and flexible cord for the leads soldered on and the joints taped.

Each primary coil consists of 306 turns of No. 19 wire; there are 22.77 turns to the inch and 22.77 × 7 = 159.39 turns to the length of the coil, which will make about two layers for the primary coils. Flexible leads are soldered to the primary winding and the whole is bound lengthwise, that is, inside and out, with webbing and thoroughly painted. The coil should now be wrapped with oiled cloth.

In building up the cores the sheets of iron should be cut in different lengths. For example, referring to Fig. 2, cut half the sheets 7½ in. long and half 10.5 in. and assemble them with alternate strips, long and short; then securely rivet the bundle. The yokes should be assembled in like manner, which will allow the ends of the yokes and those of the cores to mortise. One yoke and two cores can be assembled and riveted, the coil slipped on and the second keeper placed in position and riveted. The coils should be so connected that the current flows in opposite directions in the two legs.

The I^2R loss should be checked after calculations are made and if too great, should be decreased by increasing the size of the wire. This is a cut-and-try method to secure the proper size of wire.

Just for Fun

[In the issue of Jan. 19 we asked for accounts of stupidity in a class with those printed in the same issue under the heading, "Some Original Ideas." Following are a few of the best stories which have been received.—EDITOR.]

The following method of laying up three 18-ft. by 72-in. return-tubular boilers was at least unusual. After pouring 18 gal. of cylinder oil through the top manhole, the boilers were filled and then slowly drained. The man in charge expressed an opinion that the boilers would be protected from rust indefinitely; in which I presume he was correct. The removal of the oil, however, upon resuming operations will call for another original idea.—*Ernest A. Tichenor, South Connellsville, Penn.*

A student taking an examination in steam engineering was asked what a "self-supporting stack" was. He answered that it was one which paid the interest on the investment by using natural instead of fan draft.

A turbine test man was sent to the stockroom for putty and came back lugging a 50-lb. keg of white lead and asked for some dry putty, as the new stuff was too soft. [This last joke looks "putty" thin to us.—EDITOR.]—*R. Blumenfeld, Brooklyn, N. Y.*

In a small town a short distance from New York City a town meeting was called to consider alterations to the steam-heating system in the high-school building, as it was not working properly. A member of the school board made a report, with recommendations, which was severely criticized by one of the Board of Aldermen, who made the following statement:

"The heating plant was not installed correctly in the first place, for the boiler is in the wrong end of the building, as it is now in the south end and should have been placed in the north end, because steam in pipes will flow better from north to south than from south to north."

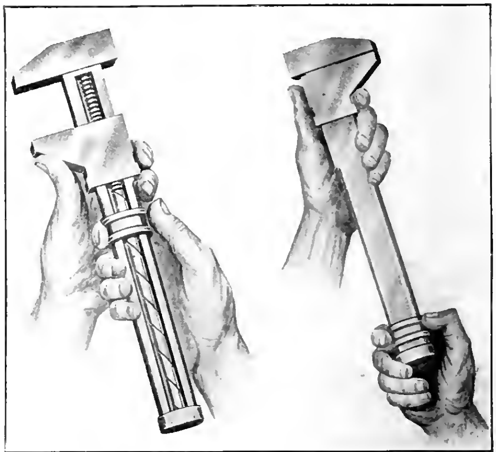
The above statement was actually made in public, and if desired, I will furnish proof of its authenticity.—*W. A. Armes, Norwood, Mass.*

During the recent cold spell I noticed a large bulged place on the brass plunger of a deep-well pump temporarily out of use for repairs, which resembled a snake after swallowing a large toad. On examining the piston it was found to be burst a distance of five inches, due to water leaking past the threads on the rod and freezing solid. On the same repair job it was necessary to take down a part of the discharge line which contained a three-inch gate valve. On removing the valve it was turned around several times. Anyone would have thought all the water had been spilled out, but such was not the case, and the result was a burst valve, but it was not noticed and was put back in the line.

When all was apparently ready the valve outside was opened to the tank pressure, and a large spray of water issued from the ruptured valve, of which a bystander and myself soaked up a good supply. The young man thought it was from over-pressure, and explained it to the fireman by saying that he saw it open up like a clam shell.—*W. H. Corbin, Sharples, W. Va.*

Bayer Quick-Acting Monkey-Wrench

A quick-acting and convenient monkey-wrench differing from the usual design has been placed on the market by the Bayer Steam Soot Blower Co., of St. Louis. The ordinary thumb-nut is replaced by a sliding collar which may be moved up and down the handle to operate the jaw. The motion of the collar is transmitted to the screw of the wrench by means of a pin attached to the collar and fitting into a spiral groove in the screw rod. Moving the collar toward the outer end of the handle closes the jaws and *vice versa*. When the collar is up against the movable jaw the wrench is wide open. In this position the



BAYER QUICK-ACTING MONKEY-WRENCH

wrench may be slipped over a nut. A pull on the collar will adjust the jaws, and pressure to do the turning may be applied at the same instant.

Including the cap at the end of the handle, the wrench is made up of five pieces: The handle and stationary jaw, the movable jaw, the collar, screw rod and cap. The handle is a solid steel forging of elliptical shape with a recess for the screw rod. The latter is thus protected so that there is little opportunity for bending it or getting it out of alignment. The collar is easy to move, and altogether, the wrench is a most convenient tool.

Heat Value Calculation—The combustion of a given element always results in the generation of a fixed amount of heat. Thus, when a pound of pure carbon burns completely (forming CO_2), 14,600 B.t.u. is produced. Consequently, the heat value of carbon is said to be 14,600 B.t.u. per lb., which is the unit of weight almost universally used in this country. When a pound of pure carbon burns incompletely (forming CO), only 4450 B.t.u. is produced. But if, in turn, the resulting $2\frac{1}{3}$ lb. of CO, which is a combustible gas, is burned, 10,150 additional B.t.u. is liberated, making the total heat produced equal to 14,600 B.t.u., just the same as though the pound of carbon had burned completely (to CO_2) in the first place. Hence, the heat value of CO is

$$\frac{10,150}{2.333} = 4350 \text{ B.t.u. per lb.}$$

The heat values for carbon and hydrogen were established by experiment and hence probably are not absolutely exact. In fact, some authorities give values for carbon as low as 14,220 and as high as 14,647, and for hydrogen as low as 61,816 and as high as 62,032, but 14,600 and 62,000 are the most widely accepted and used.

Step-Bearing Accumulator for a Vertical Turbine

By W. R. Bankhead

In the power plant at the Puget Sound navy yard there is a 500-kw. vertical turbine, the step bearing of which is supplied with oil by two duplex pumps capable of delivering oil at 800 lb. per sq.in. The oil passes through a baffle before reaching the bearing, which reduces it to a pressure sufficient to support the weight of the moving parts. This pressure varies from 155 lb. at no load to 190 at full load. These pumps also supply oil to the other bearings of the turbine and to a tank for a gravity system.

The step bearing has been burned out several times on account of the failure of the oil pressure. The pumps originally had no governor nor air chamber to steady the pressure. A failure for one second would cause the bearing to begin to cut, and the machine had to be shut down for repairs.

An accumulator of some kind was needed, and as the space was limited it was decided to install a vertical steel tube, into the bottom of which the oil should be pumped, compressing the air in the top of the tube, which acts as a spring to force the oil out to the step bearing in case the oil pump failed. This form of accumulator is cheaper to build than a weighted-piston type, costing only about one-half as much.

The tube is 11 ft. long, 12 in. inside diameter, and ½ in. thick, and is made of seamless rolled steel. In each end of the tube ¾-in. steel heads were welded by the oxy-acetylene process, and when tested to 2000 lb. hydrostatic pressure it was found to be tight; this is necessary to

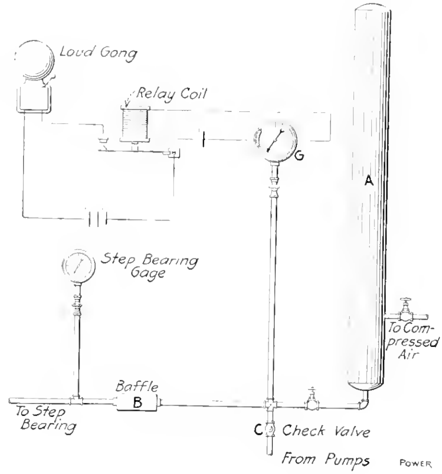


Fig. 2. Details of Alarm System

make such an accumulator successful. There is a check valve between the pumps and the accumulator and a gage

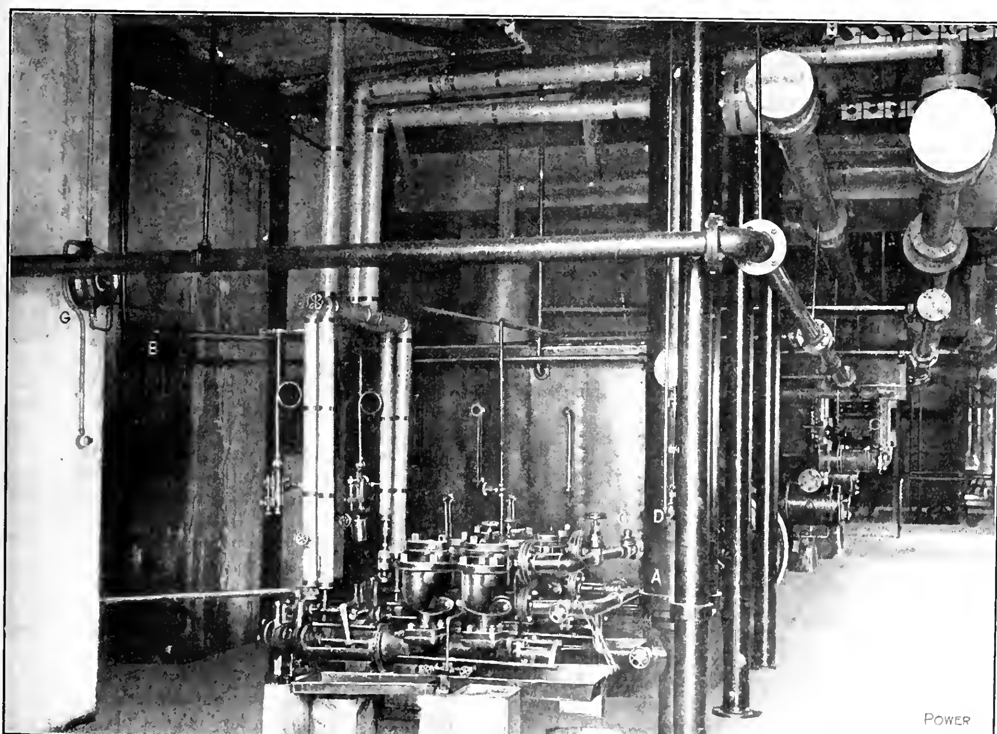


Fig. 1. Vertical Accumulator A in Limited Space near Oil Pumps

between the accumulator and the baffle. The gage is so fitted that when the oil pressure falls below 600 lb., a gong which can be heard all over the engine room announces the drop in pressure.

Fig. 1 shows the location of the accumulator *A*. The baffle *B* is at the base of the turbine foundation, and *C* is the check valve between the pumps and the accumulator. *D* is the connection to the compressed air. The high-pressure oil gage which closes the electric circuit is shown at *G*. The accumulator was first filled with compressed air at 100 lb. to insure a good supply and to reduce the quantity of oil necessary. Fig. 2 shows the details of the alarm system.

The primary purpose of this accumulator was to guard against a sudden failure and to give the operator warning in time to start another pump or to shut down the turbine. For 12 min. after the pump is stopped the accumulator will maintain a pressure sufficient to support the step bearing with the forced lubrication system still on, and for 23 min. to the step bearing only.

In practice it has proved better than was expected, as it keeps steady pressure and acts as a governor for the pumps, which can be run on a wide-open throttle.

The turbine has been running almost continually for eight months day and night without any step-bearing trouble whatever.

Instead of being an uncertain and unreliable machine, the accumulator has made this turbine one of the most dependable in the plant, and we have been able to "forget" the step bearing.

Setting the Valves of a Four-Valve Engine

By H. Wiegand

SYNOPSIS—Tells in a simple and thorough way how to set the valves of a four-valve engine to run either over or under.

In setting the valves of a four-valve engine the usual method of placing the engine on the center is used. A tram may be used to facilitate marking the different positions of the crosshead, crank, etc.

Turn the engine, which is supposed to run over, until the crosshead is at the point of the crank end release *R*, Fig. 1, which shows the positions of the crosshead, crank, throw of eccentric and rocker-arm in diagram form. As the crank-end exhaust valve must be line to line with the port to open and, when the crosshead is at *C*, begin to close for compression, it is evident that the rocker-arms must be in the same place at these two points of crosshead or crank position.

Therefore, it is not necessary to connect the valves until the right position of the eccentric has been found. Set the throw of the eccentric near the angle of advance point *B*, and mark the position of the rocker-arm line by a line across the pin and hub or hub and pin-boss; then fasten the eccentric with the setscrew or a false key and turn the engine over to the crank-end compression point

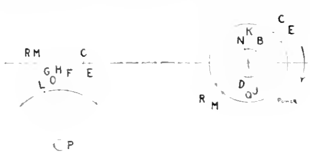


Fig. 1.

C. The throw of the eccentric will now be at *D* and the rocker-arm, instead of returning to *F*, will go beyond it to *G*. The eccentric must therefore be turned back until the rocker-arm reaches point *H*, central between *F* and *G*.

To accurately locate *H*, divide the distance between the marks on the hub and pin or pin-boss. The throw of the eccentric is now at *J* and the rocker-arm at *H*, with the crank and crosshead at *C*. Turned over to *R*. the throw of the eccentric will be at *K* and the rocker-arm will have moved to *L* and back to *H*. The crank-end exhaust valve can now be set line to line and the rods and valve lever put in the desired position. The latter may be fastened with a false key and a line drawn across the face of the lever and the valve stem to mark the position

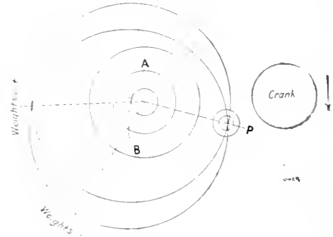


Fig. 2.

of the valve. The crank must now be turned back to *M*, the point of head-end compression, and the head-end exhaust valve connected and set line to line with the port. The eccentric will now be at *N*, the rocker-arm at *O*. Turned over to *E* or head-end release, the throw of the eccentric will be at *Q*, the rocker-arm at *O*, the crosshead at *E*, and the valve will begin to open for release. The eccentric and valve levers can now be marked for keyseating and the rods locked and marked for length. To set the admission valves, place the governor in its midway position and turn it so that with the weights "in," the throw of its eccentric is in line with that of the exhaust eccentric; then fasten it there. Next turn the shaft to its crank-end center and throw the weights of the governor out. With the valve-gear rods set at their proper lengths, set the crank-end admission valve line to line with the port and fasten the lever to the stem.

Now throw the weights in and note how far the valve has opened. The designer will give the lead and the lap of the valve at dead-centers. Suppose this valve should have $\frac{1}{4}$-in. lead and $\frac{1}{32}$-in. lap, it must move $\frac{9}{32}$ in. by throwing the weights out or in. If it does not move enough the governor must be advanced, or set back if the valve moves too much. The two large circles, Fig. 2, represent the greatest and the least travel of the eccentric. The diameters of the two smallest circles, Fig. 2, represent the greatest and least travels of the valves, the next larger one the bore of the wheel and the two large circles the positions of the eccentric with governor weights in and out. The arc AB drawn from the center of the pivot pin P marks the path of the center of the eccentric and

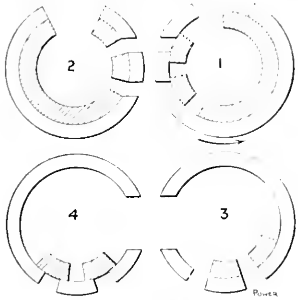


FIG. 3. POSITIONS OF VALVES

the two dotted lines drawn from the center of the wheel mark the throw of the eccentric at its greatest and at its least travel. It will be seen that the position of the governor is given by the distance between the two eccentric circles or the amount of valve motion at dead centers; also that the throw of the eccentric at least travel is opposite the crank and that it is impossible for the valves to open if they have lap at dead-center, while the governor weights are out. After finding the correct governor position the crank-end valve may be set to its proper lap and the engine turned over to the head-end center for setting the head-end valves in the same way.

Turn the engine over one revolution with the weights out to make sure that the admission valves do not open, then turn it one revolution with the weights in to note the point of admission to the point of cutoff and to see that no negative lap occurs from overtravel, which would happen

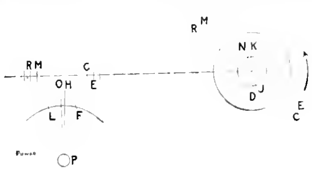


FIG. 4.

if the valve in Fig. 3 were turned further in the direction of the arrow. By decreasing the governor travel the negative lap may be reduced if it is not over $\frac{1}{16}$ in.; if more, a new valve is usually required. The governor, valve levers and rods can now be marked as described.

To reverse this engine set the exhaust valves by turning the shaft to R, Fig. 4, the point of crank-end release, when the engine is running under. Then turn the eccentric in the running-over direction until the crank-end exhaust valve is line to line with the port. The throw of the eccentric will be at J, the rocker-arm at H and, turned over to C, the throw will be at K, with the valve again closing for compression. The head-end exhaust valve will be line to line at E and C.

The weight-arms of the governor and the springs and links require changing to throw the eccentric the other way. The key has to be taken out and the governor turned in the direction of running "under" until, with the engine on its crank-center and the governor weights "in," the

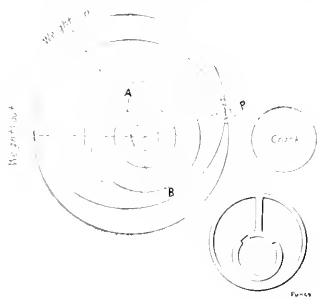


FIG. 5.

crank-end admission valve has $\frac{1}{4}$-in. lead. Fasten the governor and turn the engine under to the head center and the head-end valve will show the same lead. Now throw the weights out and examine the lap; if it is not quite right the governor may have to be moved a little either way. The engine is reversed and the new keyways may be marked.

Fig. 5 shows the position of the eccentric for running under and also the keyways for running the engine in both directions.

Wrong Voltage on Motor

By J. A. Horton

An operator complained that his induction motor was overheating and stated that it was free from grounds; that the trouble was in the motor itself because the one that it had replaced operated normally up to the time of its replacement; and that his service voltage was 550 to 600. He added that one phase took hardly any current, while the two other phases did all of the work.

As the replaced motor had operated normally, the unbalanced symptom suggested a reversed internal connection. Accordingly, a winder was sent to inspect the end connections and to change them if necessary. No changes were needed because the connections were all right. Just after trying the motor and before the oil switch had been opened, the winder approached the connections with the intention of taping some bare ones. The operator hastily opened the oil switch and warned him that the line voltage was 550 volts and that one leg was grounded through a fault. The winder was no general trouble man, but he had looked at the nameplate of the motor and, as he had seen 440 volts marked on it, he failed to see any good reason why a 440-volt motor should be operated on a 550-volt circuit. Wrong voltage was the only trouble.

As far as the unbalancing of the phases was concerned, what had seemed to be an unbalanced condition was due to the fact that the operator, in using a single ammeter on a three-phase circuit, failed to note that the current had changed while changing his meter from one leg of the circuit to the other. The three legs had not been read under like conditions of the load.

A. S. M. E. Boiler Code Approved by Council

Something of an event in the history of the American Society of Mechanical Engineers occurred Saturday, Feb. 13, when the council approved the proposed Boiler Code finally submitted by the committee appointed for that purpose. Probably no one appreciated what an important undertaking this would prove when the suggestion was first made that the society draft standard specifications for the construction, equipment and use of steam boilers with the hope that they might be made the basis of uniform legislation in the several states. Certainly no one anticipated the monumental task it would develop into, nor the keenness of the interest that would be enlisted from so many quarters, many of them unexpected. One member of the council in moving a vote of thanks to the committee characterized the code as the greatest single piece of work that the society has ever done.

In spite of the opposition that was manifested, especially in the early part of the committee's work, by the various industries which feared the code would tend to injure their business and were jealous lest others might obtain advantages over them in one way or another, all of these conflicting interests were finally reconciled; the council approved the code unanimously and even from outside of the society there is practically no objection to the code in its final form.

It is reported that immediately it became possible to secure a copy of the code in its approved form, one was rushed to Indianapolis to be embodied in a bill to be presented, and it is believed that the State of Indiana will adopt the code entirely in the very near future and that eight to a dozen other states are all ready to follow suit before many months have passed by. The council voted not to discharge the committee, but to continue it indefinitely with the idea that it may be made a permanent committee by action of the society, with power to revise the code from time to time whenever that may be warranted due to advances in the arts. This committee was augmented to include not only the original members, but the later advisory committee of eighteen members.

While the existence of the committee dates back to Sept. 15, 1911, when it was appointed during the presidency of the late Col. E. D. Meier, "to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of same in service," most of its real activity has been shown during the past year.

The council's instructions were to formulate a model engineers' and firemen's license law, a model boiler-inspection law and a standard code of boiler rules. The necessity of properly constructing, installing and inspecting boilers was naturally to receive consideration and the make-up of the committee was appropriately chosen. The accompanying portraits show the original members.

The chairman, John A. Stevens, at the age of 27 was granted an unlimited engineer's license for ocean steamship—highest class. He resigned as first assistant engineer of U. S. M. S. "St. Paul" in 1893 to take the position of chief engineer of the Merrimac Manufacturing Co. in Lowell, Mass. For eleven years he made all power-plant layouts and estimates for this company. In 1907 he was appointed by the Governor a member of the Massachusetts Board of Boiler Rules and served two terms of three years each, during the first of which the Massachusetts rules were formulated, which have since been the pattern of so many other states. Since 1909 he has practiced consulting engineering.

The other members of the committee included two professors of engineering, two boiler manufacturers, a steel-plate manufacturer and an insurance engineer.

Prof. R. C. Carpenter is professor of experimental engineering at Sibley College, Cornell University, Ithaca, N. Y., a consulting engineer with extensive practice and experience in the boiler field, the author of "Experimental Engineering" and other engineering books, and is frequently called as an expert witness in legal cases concerning boilers.

Prof. Edward F. Miller is professor of steam engineering at the Massachusetts Institute of Technology, Boston, Mass., and similarly qualified by experience. His special services on the committee were in connection with the safety-valve specifications and mathematical formulas.

Col. E. D. Meier, since deceased, was the president and chief engineer of the Heine Safety Boiler Co., St. Louis, Mo., and a builder of water-tube boilers.

Richard Hammond, president of the Lake Erie Engineering Works, Buffalo, N. Y., brought the experience of a maker of marine and tubular boilers to the committee. His advice was especially helpful in relation to rules concerning large-diameter boilers and stayed surfaces.

Dr. Charles L. Huston, vice-president and works manager of the Lukens Iron & Steel Co., and also of the Jacobs-Shupert U. S. Fire Box Co., was particularly valuable to the committee as its special metallurgical expert, for he is one of the foremost investigators into the scientific manufacture of iron and steel plate.

Finally, as the representative of the field of boiler inspection and insurance, William H. Boehm, superintendent of the departments of steam boiler and flywheel insurance of the Fidelity & Casualty Co., New York, rounded out appropriately the committee's personnel.

A first preliminary draft of the rules proposed after consideration had been given to the rules then in force in such states as had any, was prepared and distributed among authorities qualified to criticise it and make suggestions at the St. Paul meeting of the society in May of last year. The interest aroused prompted the arrangement for a public hearing in New York in the fall. This took place in September and another in October, after which the code was revised and a third printing made of the preliminary draft. The fourth printing was called a Progress Report and brought formally before the annual meeting in New York last December. The unusually extended discussion which ensued has already been referred to. Shortly thereafter there was a conference with the boiler manufacturers' association at which it was decided to revise the code at once while the suggestions were fresh in mind and submit the details to representatives of all organizations and interests who would be affected by the proposed code. The result was the appointment of the following advisory committee:

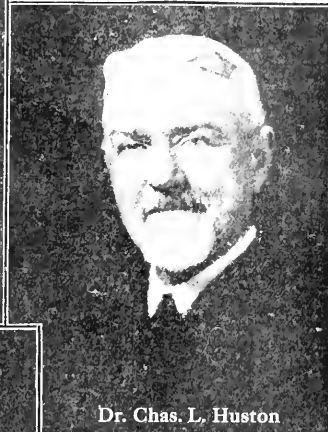
A.S.M.E. Committee on Uniform Boiler Specifications

American industries can now afford a little better boiler for a little more money, and a little more regard for human life.

Wm. H. Boehm

The United States has less legislation regarding boilers than any other civilized country—and more explosions

Prof. R. G. Carpenter



Dr. Chas. L. Huston

John A. Stevens

Col. E. D. Meier

Prof. Edwd. F. Miller

An ignorant or careless attendant can explode the best boiler ever built, and the better the boiler, the more disastrous the explosion.

The report of this committee embodies the collective wisdom of the world's best experts.

D. S. Jacobus, advisory engineer, Babcock & Wilcox Co., New York.
F. H. Clark, general superintendent of motive power, Baltimore & Ohio R.R., Baltimore, Md.
H. H. Vaughan, assistant to vice-president, Canadian Pacific Ry., Montreal, Canada.
A. L. Humphrey, vice-president and general manager, Westinghouse Air Brake Co., Wilmerding, Penn.
Karl Ferrari, Erie City Iron Works, Erie, Penn.
H. G. Stott, superintendent of motive power, Interborough Rapid Transit Co., New York.
I. E. Moultrop, assistant superintendent construction bureau, Edison Electric Illuminating Co. of Boston, Mass.
W. F. MacGregor, superintendent of experimental department, J. I. Case Threshing Machine Co., Racine, Wis.
Richard D. Reed, H. B. Smith & Co., Westfield, Mass.
M. F. Moore, assistant to president, Kewanee Boiler Co., Kewanee, Ill.
S. F. Jeter, supervising inspector, Hartford Steam Boiler Inspection & Insurance Co., Hartford, Conn.
Thomas E. Durban, general manager, Erie City Iron Works, Erie, Penn.
F. W. Dean, consulting engineer, Boston, Mass.
William F. Kiesel, assistant mechanical engineer, Pennsylvania R.R., Altoona, Penn.
Arthur M. Greene, Jr., professor of mechanical engineering, Rensselaer Polytechnic Institute, Troy, N. Y.
Charles E. Gorton, Gorton & Lidgerwood Co., New York.
Elbert C. Fisher, vice-president and general manager, Wickes Boiler Co., Saginaw, Mich.
C. W. Obert, associate editor, American Society Mechanical Engineers, and secretary to the Boiler Code Committee, New York.

The work of revision has continued without interruption, since December 15, except for Sundays and holidays including both day and night sessions. After so tedious a grind it is naturally very gratifying to the hard-worked committee that its efforts have been successful and the report received by the council. For its part the council and all the members of the society, and engineers and others outside of the society too, for that matter, should and do feel their obligation for the earnest work of the men engaged on it. Is it too much to say that humanity generally should honor these men, for their efforts are certain to result in decreased loss of life and property from boiler accidents?

New Blackburn-Smith Twin Filter

A new type of Blackburn-Smith feed-water filter and grease extractor, having twin bodies controlled by a single set of inlet and outlet valves, is built by James Beggs & Co., 38 Warren St., New York City.

A plant carrying a varying load, or one which operates twenty-four hours per day, requires a filter having considerable flexibility as to capacity, and one which would permit of the cleaning of one part while the other was in operation. If such a filter were of such size that either side alone could carry the regular load, then the two sides could be thrown in during the peak load, and so filter the water at all times without interference by the necessary cleanings. This filter, Fig. 1, is designed to meet such conditions.

The turning of both valves to one limit bypasses the corresponding body, and the other body is bypassed by turning both valves to the other limit, thus permitting the alternate operation and cleaning of either side. The combined operation of both sides, as would be desirable during the peak load, is accomplished by turning the valves to mid-position.

The filter is made up of a number of parts, so that breakage or disarrangement of any particular section does not necessitate the discontinuance of all filter service. The valves are of the double-seat type and the disk working between the seats is self-seating, which prevent leakage due to dirt deposited on either disk or seat.

The filter chests are the same as in the single type of filter, each divided into an inlet and an outlet chamber

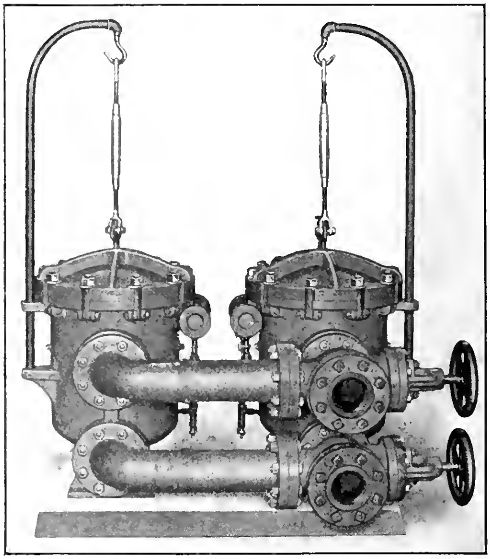


Fig. 1. New Twin Filter

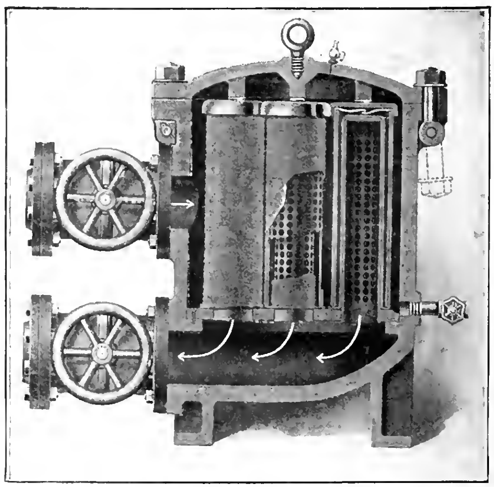


Fig. 2. Section through the Filter

by a partition carrying the filtering cartridges. Fig. 2 is a sectional view. The opening of the filter for cleaning is facilitated by the use of a cover held by swing bolts. A crane with a turnbuckle lifts, swings and holds the cover during cleaning.

Cast Iron—The average weight of cast iron is taken at 450 lb per cubic goot, or 37.5 per sq.ft., one inch thick.

Editorials

The Boiler Code's "Commencement"

College graduation exercises are significantly called "Commencement." To be sure, Commencement marks the completion of the students' college course, but the beginning of their serious or useful life. On page 268 we report the Boiler Code's "Commencement." Its course of preparation is completed and it has obtained the degree of A. S. M. E., which in this case is added before its name instead of after. A great work is done, but another great work is just beginning, without which all the labor of compiling the code would amount to naught, for until the states or municipalities adopt it into their laws and, indeed, until the laws are enforced no real good will be accomplished.

It must be gratifying to those who have given themselves so unselfishly to the task of getting the code in shape, at no inconsiderable expense of time, money and effort, to find many states and cities already eager to avail themselves of this expert assistance in getting proper statutes on their books regulating steam boilers.

This great movement to promote the safety of boiler operation has started auspiciously. As stated in the article referred to, Indiana has already prepared to apply the code and it may even be a part of this state's laws before this issue of Power reaches its readers. Indiana will thereby have the distinction of being the first to adopt the code after its approval by the council of the American Society of Mechanical Engineers. Wisconsin, however, stole the march on all her sister states by adopting it before its completion, in the law which went into effect January 1, 1915, for this law provides that the code, as soon as approved, shall become a part of it. Pennsylvania and Tennessee have departments already established, administered by the police authority, which promise to adopt the code, and Ohio, now operating under an excellent set of laws, has intimated her intention to revise them to conform with the uniform code. Active work is also being taken up in New Jersey and Florida, and the prospects for other states following suit in the near future are excellent.

To speed the good work of bringing the code to the attention of the law makers a legislative committee has been formed, representing three branches of the boiler-making industry. Its members are: Isaac Harter, Jr., of the Babcock & Wilcox Company, representing the American Boiler Manufacturers' Association; Thomas E. Durban, of the Erie City Iron Works, representing the National Tubular Boiler Manufacturers' Association; and H. P. Goodling, of the Farquhar Company, representing the National Association of Thresher Manufacturers. Thus the water-tube, fire-tube and portable boiler interests have united to bring about with all possible dispatch that condition which will be so much to their advantage—uniform requirements in all localities, so that their product built to meet one standard set of specifications may be used in any part of the country without modification.

That Power takes a keen satisfaction in this wave of reformation goes without saying. It will not imitate the daily newspapers which delight in attempting to appropriate the credit to themselves whenever a cause they have championed triumphs. While it is only fair to claim that no single institution has so consistently and persistently and for so long a time urged the need of proper laws to safeguard the handling of steam boilers as has Power, to which its pages for many years back bear witness, it suffices us that the much looked-for end is now in sight, and we are glad to bestow the credit where credit is due. We honor ourselves in saying "well done" to the men who have finally crystallized our cries and those of many others, that there should be laws, into these definite recommendations that these are the laws that should be. With this change of text we shall continue to preach the doctrine and plead for the adoption of the A. S. M. E. code.

License Activity in New York City

The Mayor and his advisers are bending their efforts to centralize the licensing of buildings, electrical work, engineers and firemen, etc., under one head, namely, the present Bureau of Licenses. As far as the Boiler Squad, which now performs the function of licensing engineers and firemen and of inspecting boilers, is concerned, the proposed plan is to allow it to continue inspecting boilers, while men from the Squad would be assigned to the Bureau to examine applicants for engineers' and firemen's licenses.

Engineers of the city have been alarmed because they understood that all of the functions of the Boiler Squad were to be exercised by another department. Because the present work of the Squad is satisfactory, a change was not looked upon with favor. But the change as proposed by the Mayor's committee is really of little significance as far as the engineers and firemen are concerned. One or two bills covering the function of licensing of various men and kinds of work in the city have been introduced in Albany, but it is too soon to tell just what disposition will be made of them. If passed as originally written the Boiler Squad will become defunct.

It must be admitted that the Police Department is not the logical body to administer the work of inspecting boilers and licensing engineers. The real solution of the question is the creation of a state board to conduct such work. This does not necessarily mean that local boards could not exist contemporaneously, as we point out editorially in this issue.

The Boiler Code Committee of the American Society of Mechanical Engineers in its report just completed, has made quite complete recommendations on uniformity of boiler construction. Probably, before very long, a supplementary report embodying recommendations as to the uniformity of boiler inspection and of the licensing of engineers and firemen will be presented. These recommendations will be scientific. They will be based upon all past experience in such work and will embody the best of all that demonstration has proved good. They will be satisfactory to all of the various interests involved.

The Boiler Squad has been guilty of disreputable acts in the past. It is likely to go wrong again at any time, and those interested would again be confronted with the old conditions. If there must be local boards in New York and Buffalo, the two cities that have combated a state law the hardest, let them have them, but they should conform to the regulations of the state board.

It is not too soon for engineers and owners in New York who are interested in their own welfare and in public safety, to create sentiment favoring a state law embodying the recommendations of the American Society of Mechanical Engineers as to uniformity in construction, inspection and licensing.

State and Local Inspection Departments

In states where some of the principal cities are already provided with departments for inspecting boilers and examining and licensing engineers, efforts to pass a state law are hampered by the opposition of local politicians and officials, who fear the loss of the patronage and positions which go with the municipal ordinance. There is also to be dealt with the Home Rule sentiment, and the natural reluctance to give up a successful local administration for one administered from the capitol, which would have less direct contact with local men and conditions.

But the state-wide law need not involve the abandonment of the local systems. Most of the state laws either exempt from inspection boilers which are under the care of boiler-insurance companies authorized to do business in the state, or, better, accept the findings of inspectors of such companies after such inspectors have been approved by the state department having charge of boiler inspections, thus becoming pseudo state officials, although in the pay of their respective companies. In this way the state department has a record of all boilers and is as well assured of their satisfactory condition as though they were inspected by men paid by the department itself.

The same principle may well be, and in Wisconsin is, extended to municipal departments. The local board goes on making its own inspections and examinations, granting its own certificates, keeping its own records, and collecting its own fees, but in addition reports to the state department, which is thus able, in connection with its own work in those parts of the state which have no local system, to keep a complete record of all the boilers and engineers in the state and to exercise some supervision over the whole. The state board may, for example, adopt a code of boiler rules, such as that recently completed by a committee of the American Society of Mechanical Engineers, the requirements of which would be enforced by the local and insurance, as well as by their own inspectors. This would result in uniformity of practice, not only as between different parts of the same state, but, it is hoped, as between the states themselves, for state boards would probably avail themselves of the expert work which has been expended upon the production of this code, and all adopt practically the same requirements. An association of the heads of state departments could be a clearing house for information deduced by the investigations and experience of each, and by recommending revisions of the code as the advisability of such revisions develop, maintain substantial uniformity throughout the nation. And the local inspectors would be a part of the system and in line for advancement to the positions of larger responsibility and emolument which it offers.

The Exposition Opens

February 20 the greatest world's fair to date opened its gates. Our leading article this week is an extensive account of the Exposition, covering somewhat its general features, but more particularly such as will especially interest the engineering field. This is the first of a number of articles which we expect to present, dealing more in detail with the exhibits with which our readers will be concerned, and in the fall an account will be given of the International Engineering Congress, which likewise will be the most notable that has occurred.

The Exposition stands as a commemoration of the greatest piece of engineering in history—the connecting of the Atlantic and Pacific by a canal across the Isthmus of Panama, the benefits of which to mankind will continue down the centuries. The Exposition can hardly have so far-reaching an effect, but if it repeats the experience of like undertakings of the past it will mean much in furthering the progress of all lines of human endeavor by showing what has thus far been accomplished, and thereby indicating the directions in which continued improvement is to be desired.

A fair of this kind is, naturally, of most direct advantage to those who can visit it, and no one who has the opportunity to get to San Francisco should neglect it. It is a liberal education in itself. Next best is to read the descriptions of it which will appear in the periodicals of all kinds. This, too, is an opportunity not to be overlooked. Present-day achievements in the illustrating and printing arts bring within the means of all the ability to gain much of the good that would come from an actual trip to the Fair. But seeing the Fair and reading about it both require a disposition on the part of the individual to avail oneself of the opportunity to broaden one's knowledge.

More indirect, but of certain advantage to the most indifferent, is the influence which such an exposition has on the world at large by stimulating a striving for better things in all lines—art, business, profession or calling of any kind—in consequence of the examples set by the exhibits and in other ways. No one can visit such an impressive collection of the world's best without coming away with new ideas to apply, and these in turn inspire those who do not go.

Innumerable endless chains of uplift are started with every such demonstration of modern achievement. The greater the undertaking, the greater the effect. If argument were needed it could be continued *ad infinitum* to justify all the stupendous labor and expenditure involved in the Panama-Pacific Exposition. Thanks be for the inspiration that conceived the idea and the energy which carried it to fruition!

Correspondence

Cost of Steam

H. L. Strong's article on page 133 in the issue of Jan. 26, under the above heading, strikes an important note. Every engineer is interested and anxious to know how much it costs to make steam in the other fellow's plant, but the mere statement that A's steam costs 25c. per thousand pounds does not tell it all. However, it may be used as a basis for comparison and a standard method of arriving at this cost should be used. The statement should contain the following items: Coal, ——— lb. at ———; Water, ——— gal. at ———; Power for Electric-Driven Auxiliaries; Labor; Miscellaneous Expense; Maintenance; Fixed Charges. The first three items are self-explanatory.

Under "Labor" should be charged supervision, foreman, fireman, ash- and coal-conveyor operators, boiler cleaners, ashmen and shovelers, helpers and laborers, and all other labor, aside from maintenance, incident to operating the station.

"Miscellaneous Expense" takes care of oil, waste, etc.

"Maintenance" should include labor and materials required to maintain in proper condition buildings, stokers, conveyors (ash and coal), boiler-room auxiliaries, pipes and fittings, feed pumps, electrical apparatus, and all other tools or apparatus used in the boiler room in connection with making steam.

Under "Fixed Charges" should be charged depreciation of buildings and equipment, insurance (boiler and fire) and taxes.

The sum of these items gives us the total cost of producing steam. This sum divided by the net amount of steam generated, from and at 212 deg. F., and multiplied by 1000, gives the cost per thousand pounds of steam, from and at 212 deg. F. "Net" steam is the steam produced by the boilers which is available for power, etc. It is the total feed water less steam lost by blow-down and that used by boiler-room auxiliaries, or the amount registered by flow meters on the outlet from each boiler, less the steam used by auxiliaries. From records of steam pressure and feed temperature it is a simple matter to reduce to pounds, from and at 212 deg. F.

After following the above form or an equivalent and arriving at the cost of steam per thousand pounds, there are three important items to be considered before the costs in different plants are comparable. These are (1) cost of fuel, (2) load factor, and (3) equipment.

(1) *Cost of Fuel*—If the cost of the coal used in two plants is known and the charges against cost of steam are kept in accordance with the foregoing form, it is a simple matter to adjust the charges and determine what the total costs would be if the fuel costs were the same. For instance: A burns 2000 tons of coal per month, at $4 per ton and his steam costs 28c. per thousand pounds. If his coal cost him $3.50 per ton the total charges for the month would be $1000 less and, consequently, the cost per thousand pounds of steam would be correspondingly lower.

(2) *Load Factor*—The character of the load on a boiler plant has considerable to do with the cost of output. A plant whose load is steady, with small fluctuations, such as a central lighting and power plant, can produce steam cheaper than, say a plant supplying an industry where steam is used for driving engines or turbines, for drying ovens, for miscellaneous manufacturing purposes and for testing manufactured apparatus, under which conditions it may be necessary to carry banked fires under one thousand horsepower or more of boilers. In order to keep costs comparable, the coal used for banking should be kept account of separately from that used for loaded boilers. Only the coal used for actually producing steam should be charged to the cost of steam. This banking, or stand-by, coal should be charged to the departments responsible, and should not be charged to one boiler plant when making cost comparisons with others.

(3) *Equipment*—There is no way of bringing a variety of equipment to a standard basis. However, if the other two factors are made equitable, then, if there is much difference in the cost of producing steam in two plants, it is fair to claim that it is due to equipment and management, and the plant which shows the cheaper production should be given the credit for having the more efficient equipment and organization.

C. W. Howard.

Erie, Penn.

Purchasing Coal

Under the above caption, in your editorial in the issue of Jan. 26, you say all coal mined must or should be used as fuel. Your argument is good as far as *all coal* is concerned, but if the substance delivered at the plant contains 15 per cent. or more of slate, then the only apparent remedy for this condition is for the consumer to protect himself by the B.t.u. clause in his contract. In the plant of which I have charge we buy all our coal on the B.t.u. basis, and since we adopted this method (three years ago) we show a saving of from 10 to 30 per cent. As to cost of analysis, it is small compared with the saving effected.

Our contract reads $2.20 per ton (2000 lb.) (nut and slack), coal to test 13,400 B.t.u. per pound (100 either up or down not to be taken into consideration), moisture not to exceed 2 per cent., ash not to exceed 10 per cent., samples to be taken with a 2-in. pipe from each load as delivered; part of each sample to be put in a can and sent to a chemist satisfactory to both parties, on the thirteenth and twenty-seventh of each month; consumer to pay for the analysis, which is $3.30 for each sample, or $6.60 per month. There are coal companies that refuse to consider any contract that has this clause included in it, which goes to show that it is a good thing for the consumer.

In January of last year there was a shortage of coal in this city, and dealers took advantage of that condition and boosted the price 50c. per ton, and delivered anything that looked like coal. Of course we got the same grade of coal that the other plants did, but we were protected by our B.t.u. clause and instead of paying $2.70 and sometimes higher, we paid $1.745. The plant consumed 264 tons that month, which if it had stood up to the guarantee of 13,400 B.t.u. would have cost us $2.20 × 264 = $580.80, but on account of low B.t.u. the price went down to $1.745 × 264 = $460.68, or $111.12 rebate.

Now, suppose we had been like the other fellow and were paying $2.70 per ton, we would have paid $2.70 × 264 = $712.80 for that same coal that cost us $1.745 per ton, or $252.12 more than we actually paid. You must admit that this is a good proposition for the consumer, your employer. If the coal runs above the guarantee of 13,400 B.t.u. you can well afford to pay the premium. To sum the whole matter up, it places the consumer in a position where he can get just what he pays for and pays for just what he gets.

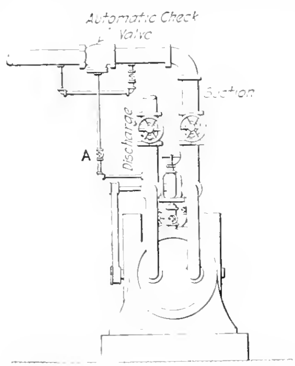
In times gone by the coal game has been in the hands of the dealer, but a B.t.u. contract evens up the game and gives the plant owner an equal show.

O. Newton.

Lakewood, Ohio.

Compressor Trouble Due to Throttled Suction Line

Several changes had been made in the equipment of a small refrigerating plant, including the addition of a compressor the size of the old one. The new machine did not produce the expected gain in refrigerating capacity; in fact, when run alone on the load it failed to do the same work as the old compressor. It was decided that the suction line was too small to serve the two machines, so a duplicate line was put in. This improved matters but little.



Compressor Connections

The suction gage on the new machine registered 8 lb. lower than the one on the old compressor when running and would increase 3 to 4 lb. after the machine was shut down. There was no gage tester available, so the increase was ascribed to inaccuracy of the gage. This compressor ran much warmer than the old machine.

An automatic check valve was provided in the suction line, as shown. One day when the machine was started the engineer was surprised to hear a hissing sound in the valve similar to that made by steam passing through a throttled valve. He found the bypass open and closed it as it should be in normal operation. This stopped the noise, but did not satisfy the engineer, for he correctly reasoned that if there had not been a considerable difference in pressure on the two sides of the check valve there would have been no hissing sound. He noticed by this time that the suction gage indicated 10 lb. lower on this machine than on the old one, which was 2 lb. greater than it had ever been before; the machine was also hotter than usual.

The valve *A* had been closed when he took charge, and he had been told by several who were supposed to know that it was to be kept closed. He opened it a few turns, and immediately the machine began to pound heavily. He closed the valves, and after a few revolutions the machine ran normal.

The engineer reasoned that there must have been an accumulation of liquid in the suction line back of the check valve, and when he opened the valve *A* this opened the check valve wide, and the accumulated liquid was swept into the machine. He decided to try again, but first he shut off the liquid line to the expansion coils and pumped down until the machines were running hot so as to be sure to prevent slugs of liquid remaining in the suction line. Now he opened the valve *A* gradually. The suction gage jumped from 10 lb. lower than the other gage to 5 lb. above, the machine cooled to the same temperature as the other, and the clattering of the valves that had always been present was silenced.

The trouble was in the check valve. This valve is intended to shut off the suction pressure in case of accident or blowout on the machine or discharge line. It depends on the head, or discharge pressure, to keep it open. The valve *A* being shut, there was little pressure in the pipe leading from it to the check valve, and consequently the check valve was nearly closed, which throttled the flow of gas to the machine. There was a welcome increase in capacity, and the new machine now does as much as the other.

Thomas G. Thurston.

Chicago, Ill.

Cement as Furnace Lining*

Part of our boiler plant consists of four 90-in. return-tubular boilers rated at 400 hp. each and frequently developing as high as 700 hp. as indicated by the flow meters. Induced draft is used, and the coal burned per square foot of grate averaged, until recently, about 20 lb. One of these boilers has a concrete setting, which in other respects is the same as for the other three boilers, which are brick set. The furnace was lined with firebrick and the bridge-wall was of the same material, but the combustion-chamber walls were bare concrete. These walls were approximately 2 ft. thick and had a 2-in. air space. I have no information as to the mixture, but apparently it was about 1:3:5 cement, sand and crushed stone.

The boiler has been in service twenty-four hours per day for about three-fourths of the time, for about ten years. The furnace lining has been renewed repeatedly, but nothing was done to the setting until a few months ago, when it was found that the combustion-chamber walls had wasted away nearly to the air space; in fact, we cut into the air space in cleaning away the burned

*See "Power," Dec. 15, 1914, p. 840; Jan. 12, 1915, p. 62; Jan. 26, p. 131, and Feb. 2, p. 169.

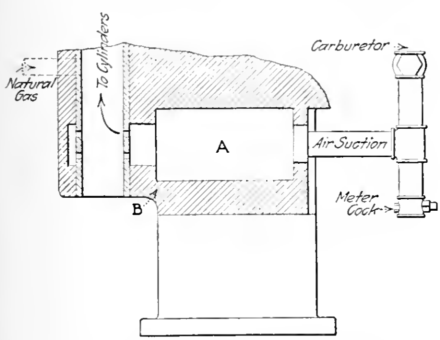
material. The only practicable repair was a brick lining, which was accordingly put in. A new concrete lining could have been put in if there had been sufficient time to allow the concrete to set or harden before using it. In other respects the setting is sound except for two or three old cracks. These boilers have not all been in the same length of time, but the two nearest the age of the concrete-set one have had all or part of the combustion-chamber linings renewed. The worst fault with concrete seems to be the difficulty of repairing, when that becomes necessary and this example seems to indicate that for boilers operated moderately a concrete setting with a fire-brick-lined furnace will last as long as the boiler.

H. L. Strong.

Yarmouthville, Maine.

Carburetion Trouble

In connecting up, for emergency use on gasoline, a small gas engine that had been operating on natural gas, considerable trouble was experienced at first in getting satisfactory operation. The engine was still to be operated normally on natural gas and was piped so that it could be switched from one fuel to the other by changing valves. The gasoline carburetor was connected to the air suction pipe as shown in the sketch, the other branch of the air pipe having a meter cock in it. By closing the meter cock and the natural-gas valve and



Section through Mixing Chamber

opening the gasoline supply to the carburetor the engine could be run on gasoline; and by shutting off the gasoline supply and opening the meter cock and gas valve it could be run on natural gas.

In running on gasoline it was found necessary at first to give the carburetor needle valve one full-turn opening and after about a half-hour's run the engine would begin to cough, backfire, and slow down. Then if the supply were shut off for a minute it would pick up again and run along all right for about another twenty-minute period, when the backfiring and slowing down would recur. The trouble lay in the fact that the gasoline, having to travel quite a distance from the carburetor through the air pipe and the chamber *A* to the cylinders, would not all stay in the gaseous form, but would partly liquefy and form a little pool in *A*. The engine would draw from this pool as well as from the carburetor, and would get too rich a mixture and start to backfire and slow down.

A small hole was drilled at *B* with the idea that the air suction through it would help to volatilize the gasoline which collected at the bottom of *A*. This helped matters somewhat, but still the operation was not uniform.

The trouble was finally remedied by connecting one end of a flexible metal tube to the air intake of the carburetor, the other end being attached to a "stove" around the engine exhaust pipe at its hottest point. This gave the carburetor hot air, and the gasoline remained in a volatile condition throughout its passage to the cylinders. The operation was then uniform and satisfactory, and the best running point of the carburetor needle valve was found to be one-half turn instead of one turn, as previously.

D. N. McClinton.

Pittsburgh, Penn.

Emery around a Dynamo

Commenting upon the letter of Mr. Weaver in the Dec. 15 issue on "Emery around a Dynamo," I believe that if his rules and advice were generally followed it would lead to trouble and give repair men plenty of business. The use of emery on either commutators or brushes should be condemned, as even with the utmost care particles of emery are likely to become embedded in the mica, brushes or commutator bars and cause no end of trouble by cutting and scoring the bars or brushes.

The use of oil on a commutator is another bad practice that is far too common. If it is necessary to provide a lubricant for the commutator a brush with a small percentage of graphite should be used. Oil is bound to get into the mica and in time will help carbonize it, causing short-circuits between the bars; which, in turn, will cause the brushes to spark and the commutator to pit and wear.

If a commutator is badly worn or out of true it should be turned off, and if properly done, there will be no need to use a file. After turning, the final finish is obtained by the use of fine sandpaper and any burrs of copper left from the turning can be picked or cut out with the point of a knife or tool. Should the commutator not be in bad enough condition to need turning, it can be trued by "stoning." Sand-stones for this purpose can be obtained in any desired grade and in various shapes; a handy size being 2x2x4 in. in a medium-coarse sand.

In stoning generator commutators the brushes should be lifted and the stone applied with a fair pressure. In the case of motors in operation it can be accomplished the same as sandpapering. After stoning, a finish is obtained by the use of fine sandpaper, and then all dust should be blown off with a bellows or hose and the commutator wiped with a dry rag.

After turning or stoning a commutator it is advisable to fit the brushes. This is done by placing them on the commutator under pressure and running a piece of fairly coarse sandpaper back and forth under the brush with the sand side toward the brush. This will grind the brush down to a surface that conforms to the curvature of the commutator.

There are many different grades of brushes for use for different services. It sometimes occurs that the bars of a commutator are soft and wear faster than the mica, resulting in high mica. An abrasive brush on a commutator of this sort will cut the mica and the bars at an even rate, or in a case of this kind it is good practice to undercut the mica slightly. Proper undercutting will not cause excessive brush wear. Undercutting is usually advocated on high-speed machines and is rarely resorted to on low- or moderate-speed machines, unless, as has been said, the mica tends to remain high between the bars.

After the commutator of a machine is in good condition it will only be necessary to wipe it off occasionally with a dry rag. The brushes also should be wiped off occasionally, but in the majority of cases should not be removed to do so, as there are few holders in use that will permit of the removal of a brush and its exact replacement relative to the commutator surface. Lifting the brush slightly off the commutator allows wiping it off.

BEN. J. OPPENHEIM.

Bound Brook, N. J.

Results of Changes in Boiler Furnace

The furnace changes and results obtained, as described in the article of this title by Morgan B. Smith, appearing in POWER, Jan. 19, p. 92, are similar to what was done by Westinghouse Church Kerr & Co. under the writer's supervision at the plant of the Detroit Edison Co., at Delray, Mich., in 1909, 1910 and 1911, which work was referred to in the discussion of Dr. D. S. Jacobus' paper on "Tests of Large Boilers," in the 1911 Proceedings of the American Society of Mechanical Engineers.

In the furnaces at Delray the stoker arches were cut back and the division walls between the stokers were at first constructed so as to come no higher than the fuel bed. Later, we went a step further, eliminating the division walls between the stokers, moving them together so as to present a continuous grate surface across the furnace, and substituting a short flat suspended arch for the customary construction. By these changes all brickwork other than the inclosing walls was removed from the furnaces, the troubles with the arches were eliminated and better combustion conditions were obtained.

It is interesting to note that the results obtained by us some years ago in the furnaces at the Delray plant are confirmed by those reported by Mr. Smith at this later time from the use of a similar construction.

H. O. POND,
Westinghouse Church Kerr & Co.

New York City.

Decreases the Oil Bill

The work of the power engineer is now primarily concerned with the diminution and prevention of losses more or less secondary in character. One of the best examples of this kind that have come to the writer's attention is that of the lubricating oil for one of the largest New York City office buildings. When this plant was originally installed a high-grade cylinder oil costing about fifty cents a gallon was used, and the oil caught by the separators allowed to run into the sewer.

The first economy was the connecting of all oily drips to a common receiving tank, from which it is pumped to two centrifugal oil separators. These separate the oil and water, the oil being returned to the filters and then to the oiling system. The water is returned to the feed-water heater and from there to the boilers.

The next step was the purchase of graphite lubricators to be used with the cylinder lubricators on the engines, pumps, etc. The graphite lubricators are filled with a paste made of graphite and cylinder oil and connected in between the cylinder lubricator and the steam pipe. The oil from the cylinder lubricator in passing over the graphite picks up enough to form a mixture of graphite and oil, which lubricates the cylinder. As the lubrication is done by the graphite, it is possible to use a much lower grade of oil, because the latter acts principally as a carrying agent for the former. In the case under discussion it was possible to use a 25c. oil, which, with the cost of the graphite, reduced the cost from 50c. to under 30c. per gal.

The separators in handling the oily drips discharge the water and oil as formerly, and also catch and retain the graphite on the plates. These are cleaned every week and the graphite is used in the boilers in place of compound. This system has been in operation for some seven or eight years, and the oil is used over and over without showing any reduction in lubricating qualities. The make-up oil required costs less than $250 a year, and it is calculated that the savings effected pay for the cost of the equipment about once every 11 months. The cost of the separators was about $500 each and the graphite lubricators $15 each. The equipment for this change cost less than $2000 and returns a profit of fully 100 per cent.

W. L. DURAND.

Brooklyn, N. Y.

Changed Gear Ratio

Changing the gear ratio of a motor drive is not a wise procedure unless the person making the change knows the probable result. A change that will slow the armature may increase its load beyond safe limits, and a change that will make the armature run faster may increase its speed beyond the tensile limit of its band-wires. The folly of random gear changes on direct-current traction vehicles of various kinds can be testified to by some crane and car operators. Induction motors, while similarly subject to overloads incident to decreased gear ratios, offer the assurance that they will never exceed synchronous speed very much, even when driven by the gravitation of their connected load, and will never reach synchronous speed when driven by the current alone. Above synchronous speed, alternating-current motors have a tendency to load themselves by generation.

There are times when changes in gear ratio may be productive of improved operation. An operator of a large locomotive turntable had a gasoline engine installed on one end of the table. The engine did well until traffic increase demanded faster motive power. He then supplemented it with a three-phase induction motor, installed on the opposite end of the table. The motor handled the work twice as fast as the engine had, but for several reasons, including variable voltage, variable frequency and abusive handling, it began to give trouble by heating. Ammeters showed that the motor was never overloaded except at starting, but that it was starting a large proportion of the time. To ease the starting, the gear ratio was increased 20 per cent. This stopped all trouble without materially affecting the speed of operation, because the armature ran faster.

J. A. HORTON.

Schenectady, N. Y.

Inquiries of General Interest

Highest Temperature of Feed Water with Open Heater—Why cannot the temperature of water in an open feed-water heater be raised higher than 212 deg. F.?

H. R.

Because the water is under atmospheric pressure, and 212 deg. F. is the temperature at which water is converted into steam at that pressure.

Relative Transmission by Rubber and Leather Belting—What thicknesses of rubber belting are equal for transmission of power to single and double leather belts?

R. C.

When made of cotton duck weighing two pounds per yard coated with best India rubber, 3- and 4-ply rubber belting is usually taken as equal to single leather belting and 5- and 6-ply as equal to double leather belting.

Total Heat of Steam—What would be the total heat of a pound of steam at gage pressure of 100 lb. per sq.in., with a barometric pressure of the atmosphere of 28.5 in. and temperature of 62 deg. F.?

S. G.

One inch of barometric pressure at 62 deg. F. is equal to 0.491 lb. per sq.in., and therefore the absolute pressure of the boiler steam would be

$$100 + (0.491 \times 28.5) = 113.99$$

or practically 114 lb. absolute, and according to Marks and Davis' steam tables, a pound of steam at the latter pressure would contain 1188.7 B.t.u. above 32 deg. F.

Wetter Steam Requires More Feed Water—When our boiler is pushed to its highest capacity, why is it that the water level gradually goes down, but as soon as the damper is partly closed and with the feed pump operating at the same speed, the boiler-water level comes up again?

C. J. P.

It is quite likely that when the boiler is forced wetter steam is generated, and although doing the same amount of work, greater weight of steam of the lower quality is discharged from the boiler, thereby requiring replenishment of feed water in excess of the rate required for maintaining the proper water level with the damper partly closed.

Regulation of Oil Burners—In the use of oil burners how can the best regulation of the oil, steam and air supply be determined?

A. C. S.

The best regulation of oil burners is obtained by observation of the top of the smoke-stack and the color of the fire. When the burner valves and the air supply are correctly adjusted, the flame is a bright white and there is no smoke. When the supply of steam is too great, steam will appear around the burning spray and will be discharged from the smoke-stack. If too little steam is being used, atomization will be incomplete, and if the air supply is insufficient the color of the flame will be red, and incomplete combustion will be indicated by the discharge of smoke from the stack.

Advantages of Extended Front Boiler Setting—What are the advantages and disadvantages of an extended front setting as compared with a flush front setting for a horizontal return-tubular boiler?

W. C.

The principal advantages of the extended front are the employment of a shorter brick setting and obviation of passage of the furnace gases direct to the front smoke connection, as is likely to occur with a flush front setting, from settling of the fire-door arch or other causes of leakage of the joint between the fire-door arch and the under side of the boiler. The disadvantages are that with a low setting the front extension may be in the way of the fireman, and also that the extended front does not present as good an appearance as the flush front.

Depth of Front and Back Connections for Return-Tubular Boilers—What should be the depth of front and of back smoke connections for horizontal return-tubular boiler settings?

G. R.

The depth of back connections for any size of boiler should be not less than 24 in., so as to allow sufficient space for examination and expansion of tube ends in the back tube sheet, and for boilers larger than 66 in. in diameter the depth of back connections should be not less than 28 in. Greater depth is advantageous for equalizing the distribution of the heated gases to all tubes of the boiler. Front connections should be of such form and depth as to permit of an easy sweep of the gases to the uptake. The minimum depths should be 12 in. for boilers up to 54 in. diameter, 16 in. for boilers 60 and 66 in. diameter, and 18 in. for boilers 72 and 78 in. diameter

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Operation of Centrifugal and of Inertia Governors—What is the difference between the operation of centrifugal and of inertia governors?

J. E. B.

In centrifugal governors a change in position of the governor parts is effected solely by a change of centrifugal force resulting from a change of speed. In inertia governors, revolving weights are so arranged that when the engine wheel is accelerated, as by removal of load, the inertia of the weights causes them to lag behind and assist centrifugal force in adjustment of the valve gear for admission of less steam, thus checking the speed, while if the speed of the wheel is retarded, as by an increase of load, the momentum of the weights causes them to surge ahead and assist the spring action of the governor to attain a position of parts that will increase the speed. Therefore, inertia governors are prompter than centrifugal governors, and also may be more powerful and closer in regulation.

Air Required for Burning a Ton of Coal—What volume of air should be supplied for burning a ton of coal?

B. S.

Most fuels require between 11 and 12 lb of air per pound of fuel, according to their analyses, and it is usual to consider that 12 lb. of air will be required to burn each pound of coal. But to make sure that each atom of carbon will meet with an abundance of oxygen, it is necessary to admit an excess of air to the furnace, the amount depending on the force of the draft. With natural draft at least twice as much and with forced draft at least $1\frac{1}{2}$ times as much air will be required. As one pound of air at 62 deg. F. has a volume of 13.14 cu.ft., then for burning a ton (2000 lb.) of coal the air supply should be not less than

$$12 \times 2 \times 13.14 \times 2000 = 630,720 \text{ cu.ft.}$$

of air with natural draft, nor less than

$$12 \times 1\frac{1}{2} \times 13.14 \times 2000 = 473,040 \text{ cu.ft.}$$

of air with forced draft.

Loss of Water Level in Gravity-Return Boiler—What may be the cause and remedy for occasional loss of proper water level in the sectional boiler of a low-pressure gravity-return steam-heating apparatus?

H. B. L.

The proper water level will not be maintained by automatic return of the water of condensation to the boiler when the temperature of steam in the pipes or radiators is so much reduced by radiation of hea hat the pressure, plus the static pressure of the return connection, is less than the sum of the pressures required for overcoming pipe friction, and opening the return check valve added to that in the boiler. Under these conditions the water level may also become reduced by the water of the boiler backing up into the system through leakage of the return check valve. The remedy is to obtain higher relative pressure in the return water by increasing the sizes of steam supply pipes or increasing the static pressure of the return water by raising the level of pipes and radiators or lowering the boiler.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

The Elasticity and Endurance of Steam Pipes*

By C. E. Stromeyer

In the present paper it is proposed to inquire into the causes of steam-pipe failures by dealing with about a hundred reported explosions which have been attributed to fatigue and to want of elasticity, though it may have to be admitted that bad material and workmanship, including injudicious or unnecessary annealing, have occasionally either accelerated the failures or have been their chief causes.

In dealing with this subject it will first be necessary to fix on a standard of comparison for the fatigue stresses which may have caused the failures, but in order not to complicate this subject, and also because definite information is not available, it will for the present be assumed that Guest's law for steel also applies to copper, which means that the circumferential stresses in pipes, due to internal steam pressures, do not affect the bending stresses which in the cases under consideration have caused the fractures. Then, also, nothing is as yet known about the influence of temperature on the power of copper to resist fatigue stresses, though it is probable that it has a weakening effect; but temperature also increases the elasticity of copper, so that as regards deformations due to fatigue stresses no serious error will be committed by leaving these two temperature influences out of account.

According to experiments the relationship between the fatigue stresses ($\pm S$) and the number (N) of the stress cycles (revolutions) which cause fracture is expressed by the formula

$$\pm S = Fl + C\,(10^6 \div N)^{1/4}$$

Here C is a constant depending on the nature of the material and Fl is the fatigue limit of the material. Both Fl and C have been obtained by breaking a number of samples by fatigue stresses and marking off the test results on diagrams in which the ordinates were spaced to represent $(10^6 \div N)^{1/4}$. The test results were then found to lie on straight lines which, when prolonged, cut the zero ordinate at the heights Fl, which were then adopted as being the fatigue limits. These tests could naturally not have been continued to an infinite number of revolutions, and there was therefore no absolute certainty that this exterpolated fatigue limit was a reality until by improved methods of testing this point was firmly established. In other words, more recent experiments have demonstrated the fact that this formula applies not only within the range of previous experiments, say from two thousand to twenty million alternations of stress, but also to an infinite number. Wöhler's experiments, and in fact all past experiments which have been examined, confirm the above-mentioned formula.

Wöhler's experiments confined themselves to steels, except one series of tests on wrought iron, but they have been extended by the author to embrace, at least as regards torsion-fatigue tests, about fifty different qualities of steel and steel alloys, cast and wrought iron, nickel, copper, aluminum, phosphor bronze, magnalium, and other alloys, and in all cases the test results harmonized with the formula, which may therefore be accepted as correct. A matter of even greater importance than the general form of the formula is that the fatigue limit can now be expeditiously determined with greater accuracy even than the static tenacity. In one case its extreme values among eight test pieces cut from one crankshaft differed by less than ±0.4 per cent. of the mean value.

Unfortunately no bending fatigue tests have been made on copper, but this omission will be made good in the near future, and the determination of the fatigue stresses which caused fractures in copper pipes will therefore have to be based on deductions drawn from a few torsion-fatigue tests on copper bars which are summarized in the following formula, in which $\pm S_t$ is the alternating shearing stress due to torsion strains which cause failure at the nth revolution:

Copper bar as rolled...	$\pm S_t = 5.4 + 0.37\,(10^6 \div N)$
Copper bar as rolled	$\pm S_t = 5.6 + 0.51\,(10^6 \div N)^{1/4}$
Mean of above.....	$\pm S_t = 5.5 + 0.44\,(10^6 \div N)^{1/4}$
Copper bar annealed in vacuo. . .	$\pm S_t = 2.55 + 0.87\,(10^6 \div N)^{1/4}$
Copper bar annealed and chilled in water	$\pm S_t = 2.69 + 0.97\,(10^6 \div N)^{1/4}$

It having been found that on an average the bending fatigue limit for steel is about 60 per cent. higher than for torsion, the last of the above torsion-fatigue limits may reasonably be increased from 2.69 to 4.30 tons per square inch for the bending-fatigue limit for copper, and as the same comparative tests on steels show that the value of C for bending is three and a half times as great as that for torsion, the value of C = 0.97 may be increased to 3.4 tons per square inch and the formula for the bending-fatigue stresses of copper is probably

$$\pm S_b = 4.3 + 3.4\,(10^6 \div N)^{1/4}$$

As wrought-iron and mild-steel pipes are now largely used on steamers, formulas for their bending-fatigue stresses are of interest. Among the writer's own tests he finds the following results for basic steel, which is the quality of which many welded-steel pipes seem to be made:

TABLE I

	Fatigue Limit, Tons per Sq In.	Values of C, Tons per Sq.In.
British ordinary...	9.69	4.53
British dead soft.	11.26	3.92
German ordinary.....	11.34	4.10
German dead soft.	8.94	4.79
Mean for mild basic steel. .	10.31	4.33

It will be noticed that the fatigue limit for the softer qualities of basic steel, which contain about 10 per cent. carbon, are not necessarily lower than those for ordinary mild qualities, which have about 40 per cent. carbon. This is due to the presence of varying percentages of nitrogen, which element has a tenfold greater influence than carbon on the fatigue limit. The fatigue limit for cast steel is only a little higher than the above, viz., about twelve to thirteen tons per square inch.

The formula for the bending-fatigue stresses of mild steel may therefore be written

$$\pm S_b = 10.30 + 4.33\,(10^6 \div N)^{1/4}$$

Only one set of bending-fatigue tests has been made on wrought iron (by Wöhler). The results can be expressed by the formula.

$$\pm S_b = 6.73 + 4.43\,(10^6 \div N)^{1/4}$$

Among the Board of Trade reports on steam-pipe failures there are none which may be attributed to fatigue of mild steel, but there are a fairly large number of failures of copper pipes, of which a few are capable of being analyzed with the help of the above formula. The following are the report numbers of the failures in question—failures said to be due to vibrations:

Straight pipes—Nos. 948, 1113.

L-bends, like Fig. 6—Nos. 453, 854, 945, 958, 1024, 1049, 1057, 1095, 1111, 1164, 1181, 1187, 1207, 1291, 1296, 1491, 1516, 1611, 1651, 1795, 1852, 1895, 1931.

U-bends, like Fig. 9, without central branch—Nos. 480, 1011, 1021, 1069, 1172, 1185, 1313, 1426, 1435, 1501, 1922, 2105.

U-bends, with central main pipe at right angles to bend, similar to Fig. 9—Nos. 970,992, 1015, 1036, 1696.

S-bends and two L-bends placed at right angles to each other—Nos. 657, 718, 749, 772, 775, 915, 1290, 1527, 1654, 1709, 1926, 1993.

Expansion bends with straight lengths—Nos. 767, 943, 1616, 1795, 1852, 1895, 1931.

The following failures are probably due to looseness of the engine or the boilers:

Engine seating loose—Nos. 742, 833, 1013, 1160, 1355, 1443, 1666, 1922, 1964, 2021, 2088. (In these cases it is presumable that the movements were appreciably great and as numerous as the revolutions of the engines, which on an average may be assumed to be 60 per minute for six months a year.)

Boilers loose—Nos. 543, 728, 1210, 1467. (In these cases it is probable that the movements were large but few, and the empirical rule for the fatigue stresses does not apply.)

Relative movement between boilers or engines and the ship's structure—Nos. 1268, 1543, 1291, 2176.

Shaft brake and engine raced violently—No. 1216. (This pipe had many bends, otherwise the stresses might have been estimated.)

Most of the aforementioned cases cannot profitably be analyzed on account of complexity of form and absence of details. However, Nos. 958, 1049, 1181 and 1954 of the first group and Nos. 1355, 1543 and 2021 of the second group are suitable for this purpose. The estimated fatigue stresses which fractured the aforementioned ten pipes are contained in Table II.

No allowances have been made for the internal steam pressures and their temperatures, though with the exception of

*Paper read before the Institution of Naval Architects and abstracted from "Engineering," London.

2021, for which the steam pressure was 200 lb., the pressures in all the cases were 160 lb.

Case No. 1954 deserves special attention, for the estimated fatigue stresses are approximately equal to the static tenacity of copper. The fact that this pipe withstood these alternative stresses for four hours suggests either that the adopted value of C = 3.4 tons per sq.in. per 1,000,000 revolutions is too high or that the copper was of a harder quality than usual. Among the 200 cases of steam-pipe explosions reported on by the Board of Trade, only three have been found in which measurements of movements which may have caused the failures are given.

TABLE II. ESTIMATED FATIGUE STRESSES UNDER WHICH CERTAIN COPPER PIPES FAILED AFTER N REPETITIONS

Report Number	Age at Time of Fracture	Assumed Number of Revolutions	$(10^6 \div N)^{\frac{1}{4}}$	Estimated Fatigue Stresses, Tons per Sq.In.	Remarks
Failures due to Vibrations of the Engines					
958 (1)	12 months	15,000,000	0 505	6.02	Starboard pipe
958 (2)	25 months	31,000,000	0.423	5 74	Port pipe
1049 (1)	2½ years	40,000,000	0.397	5 65	First failure
1049 (2)	1 year	15,000,000	0.505	6 02	Second failure
1181 (1)	10 years	150,000,000	0 285	5.27	First failure
1181 (2)	24 hours	86,000	1 846	10.57	Heavy weather
1954 (1)	8½ years	120,000,000	0 302	5 33	First failure
1954 (2)	4 hours	14,000	2 900	13 85	Engines racing
Failures due to Loose Engine Seatings					
1355	35 months	44,000,000	0 388	5 62	Long bend
1543	4 years	60,000,000	0 359	5.52	U-bend secured to deck beam
2021	3 years	45,000,000	0.386	5 61	Long bend

Report No. 1467 mentions that the boiler rolled ½ in. Report No. 1296 mentions that when getting up steam the length between the two valves (no dimensions given) shortened by 0.47 in., and the difference of level between the two valves altered by 0.44 in., the boiler top having risen $\frac{5}{16}$ in. as compared with the ship's structure and the engine stop-valve, which had risen ⅛ in. The history of this pipe is interesting It was made of solid-drawn copper and put in service in July, 1899; it cracked near its flange Jan. 17, 1900 (five and one-half months' interval). The cracked end was cut off and replaced by a sleeve, which cracked nine hours after lighting the fires. A new sleeve of thicker copper (1¼ in.) was now fitted, which ran, say, from the end of February to July 30, 1900 (about five months), and then cracked. A new pipe with a larger bend was fitted (August, 1900), but this pipe cracked (no date given). The crack was repaired and the gland made workable. These several failures seem to have been due, not to frequent movements associated with the revolutions of the engine, but to steady stresses caused by the difference of expansion of the boiler and engine, intensified by the vibrations of the engine. No experimental data as to the endurance of copper under these conditions are yet available.

No. 1318 reports that the boiler top rose up $\frac{5}{16}$ in. and the engine ¼ in. due to the raising of the steam pressure, the two boilers separated by ¼ in., and the distance between the engine and one boiler stop-valve was reduced by $\frac{5}{16}$ in. In this case the explosion was due to imperfect brazing of one of the flanges.

To understand the stresses which arise when pipes are strained, the several possible deformations of straight and curved pipes, as represented in Figs. 1 to 5, have been expressed mathematically in Table III.

TABLE III (Figs. 1 to 5).

	Estimated Inclinations a	Estimated Displacements δx	δy
Fig. 1	$+ M \times L \div E \times I$		$+ \frac{1}{2} M \times L^2 \div E \times I$
Fig. 2.	$+ \frac{1}{2} Y \times L^2 \div E \times I$		$+ \frac{1}{3} Y \times L^3 \div E \times I$
Fig. 3	$+ \frac{1}{2} \pi M \times R \div E \times I$	$- 0.571 M \times R^2 \div E \times I$	$+ M \times R^2 \div E \times I$
Fig. 4	$- 0.571 X \times R^2 \div E \times I$	$+ 0.356 X \times R^3 \div E \times I$	$- \frac{1}{2} X \times R^3 \div E \times I$
Fig. 5	$+ Y \times R^2 \div E \times I$	$- \frac{1}{2} Y R^3 \div E \times I$	$+ \frac{1}{4} \pi Y \times R^3 \div E \times I$

M is the external bending moment shown in Figs. 1 and 3; X is the external horizontal pull shown in Fig. 4; Y is the external vertical pull shown in Fig. 5; E is the modulus of elasticity, say 13,000 tons per sq.in. for wrought iron and steel, 8300 for copper, and 4500 to 8000, or say 6000, for cast iron; I is the moment of inertia of the section of the pipe and is equal to $(D^4 - d^4)\ \pi \div 64$, where D is the external and d the internal diameter of the pipe; a, δx, and δy are the acquired inclination and the displacement of the ends of the pipe (see Figs. 1 to 5); S_b, the maximum bending stress for any moment M, is ½ M × D ÷ I, which expression can be introduced in the formulas when the movements produced by X and Y are known.

One application of these formulas can be illustrated with the help of Fig. 6, which represents half a U-bend. Assume, as was the case in Prof. Bautlin's experiments, which will shortly be dealt with, that the flange A, which is the middle of the bend, is a fixture and that a pull X is acting horizontally on the flange C. Then the bending of BC is the same as that in the curved pipe in Fig. 4, X being applied as in that figure. The bending of AB is represented by the two cases, Figs. 3 and 5, M being equal to XR and Y equal to X. Then the acquired inclination of a of the flange B is according to the third and fifth lines of Table III:

$$a = (\tfrac{1}{2}\pi\ R \times X \times R \div XR^2) \div E \times I = 2.571\ X \times R^2 \div E \times I.$$

The displacement Δ of the flange C is the sum of the displacement δy of Figs. 3 and 5, of δx of Fig. 4, and of the product of the inclination a into the radius R of the bend BC

$$\Delta = (X \times R^3 + 0.785\ X \times R^3 + 0.356\ X \times R^3 + 2.571\ X \times R^3) \div E \times I = 4.713\ X \times R^3 \div E \times I.$$

The bending moment at A is of course 2X × R, and this is equal to S × I ÷ ½D, where D is the external diameter of the pipe. On replacing I by X2R × D ÷ 2S, the stress S at the flange A can be expressed in terms of the displacement Δ:

$$S = \Delta \times D \times E \div 4.712\ R^2$$

For copper, the value of E is about 8300 tons per sq.in., so that for pipes of this material S = 1750 Δ × D ÷ R², and assuming 4.3 tons per sq.in. as being the fatigue limit for copper, the maximum permissible movement of half a copper U-bend (Fig. 6) should not exceed

$$\Delta_c = R^2 \div 405\ D$$

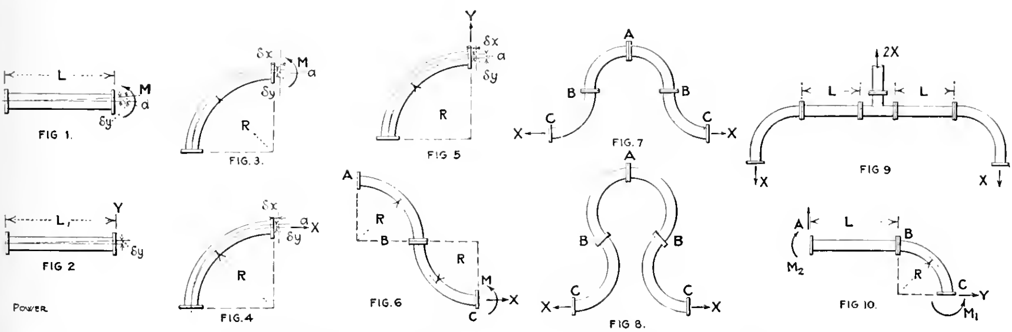
For steel and wrought iron E = 13,000, and therefore S = 2750 Δ × D ÷ R², and assuming the fatigue limit for wrought iron to be 6.75 tons per sq.in., we have

$$\Delta_i = R^2 \div 410\ D \text{ for wrought iron}$$

Assuming a fatigue limit of 10.3 tons per sq.in. for mild steel, we have

$$\Delta_s = R^2 \div 265\ D$$

Thus a U-bend (Fig. 7) of 8 in. diameter and 8 ft. high which forms part of a long length of pipe will take up the following expansion movements without injury to itself: 1.40 in. if of copper, 1.40 in. if of wrought iron, and 2.20 in. if



THE LETTERS CORRESPOND TO THOSE IN THE ALGEBRAIC EXPRESSIONS IN THE TEXT of mild steel. **This last result agrees with experiment A in Tables IV and V.**

TABLE IV. PROFESSOR BAUTLIN'S EXPERIMENTS ON THE ELASTICITY OF BENDS

Details of Bends	Height, In	Outside Diameters and Thicknesses, In	Moment of Inertia I	M I. Millions
A, mild steel pipe .	94 7	8 7 × 8 2 × 0 26	27 0	810
B, mild steel pipe.	88 8	5 3 × 5 1 × 0 175	2 65	80
C, cast-iron pipe	94 7	8 5 × 8 4 × 0 78	139 0	275
D, mild steel rod .	54 6	3 14 square	8 0	240
E, mild steel rod.	62 5	3 14 square	8 0	240

Prof. Bautlin carried out some experiments on U-bends shaped as shown in Fig. 8*. As the bends were not square other but similar formula to the above had to be constructed for estimating the displacement of the flange C. These are recorded in the columns marked "Est." in Table V. The observed displacements are to be found in the columns marked "Obs." The modulus of elasticity of the cast-iron pipe was 7870 tons per sq.in.

The formula for these bends is

$$\Delta = 17.27\ X \times R^3 \div E \times I \text{ and } S = \Delta \cdot D \times E \div 17.27\ R^2$$

It must not be overlooked that whereas in the previous case (Fig. 7) the height of the bend is 2R, in the present case (Fig. 8) it is 3.414 R. The agreement for the mild-steel rods between the estimated and observed displacements is satisfactory, but pipes seem to be rather more elastic than was expected. The discrepancies between the estimated and the observed displacement for the mild-steel pipe A have been explained as being due to slight puckers on the insides of the bends of the pipes. In part they are also due to the thinning during the bending operation. Generally speaking, Professor Bautlin's important experiments confirm the mathematical estimates of the deformations of bent pipes, and these may therefore be applied to the few exploded steam-pipes for which the probable alternating stresses have already been calculated. It is unfortunate for the present investigations that the Board of Trade reports contain so little information about those parts which, in the opinion of the reporting surveyors, are not the direct causes of the explosions. Among about one hundred reports on steam-pipe explosions, which it is believed were brought about by want of elasticity, the diameters of the pipes and the thicknesses at the points of fracture are given, but rarely is any mention made of the lengths or the elasticities of these pipes, although these are the determining factors.

For the purpose of this paper, these lengths, as well as the radii of curvature, had to be approximately ascertained by scaling them with the help of the diameters as sketched. It is therefore possible that the dimensions which have been adopted in the following calculations are not always correct.

U-bends (Fig. 9) with central branch do not seem to have failed, and this form need not be discussed.

L-bends and simple U-bends (see Fig. 10). The following formula for the displacement δy in the case of L-bends and $2\,\delta y$ for U-bends can be determined in terms of the horizontal pull Y and the bending moment M by combining the formula in Table III for the cases represented by Figs. 1, 2 and 5. As there is no pull X, and as the sums of the deflections of the length L and the bend is zero, Y can be eliminated and M expressed in terms of S_b, the maximum bending stress.

$$\delta y = 0.712\ S_b \times R^2\ (L + 0.65\ R) \div E \times D\ (L + R)$$

For copper E = 8300 tons per sq.in., so that

$$\delta y = S_b\ R\ (L + 0.65\ R) \div 11{,}600 \times D \times (L + R)$$

This formula has been used in calculating the displacements δy for the following L-bends and $2\,\delta y$ for U-bends, S_b being the fatigue stresses which have been previously determined for the separate cases.

Report No. 958 deals with the two separate L-bends made of electro-deposited copper of 5 in. external diameter hooped with iron bands. The shorter length, in which, according to the sketch, L and R seem to be respectively about 11 in. and 57 in., failed after 12 months' service. Assuming the correctness of the previously found alternating stresses of ± 6.2 tons per sq.in., the relative movements of the two ends of the pipe should by the formula be ± 0.38 in. In the longer branch, L and R seem to be respectively 75 in. and 68 in. Assuming the correctness of the previously found stresses of ± 5.74 tons per sq.in., the relative movements of the pipe ends should be ± 0.25 in.

Report No. 1049 deals with another L-bend of solid-drawn copper of 5¾ in. external diameter. According to the sketch, L and R seem to be respectively 80 in. and 25 in. Assuming the correctness of the previously found alternating stresses of ± 5.65 tons per sq.in. for the first failure after 2½ years' running, the relative movements of the two ends of the pipe should be 0.049 in., and for the second failure after 12 months' running the alternate stresses would be ± 6.02 tons and the relative movements should be 0.051 in. The comparative smallness of these relative movements is due to the rigidity of the small bend, which was only five times as large as the diameter of the pipe. In fact, the pipe probably acted as a stay between the engine and the boiler and restricted their movements while being fatigued. Had the relative movements been larger and the stresses more intense, the failures would have occurred sooner, as happened in the following two cases:

Report No. 1181 deals with an L-bend of solid-drawn copper 6⅞ in. external diameter. According to the sketch, L and R seem to be respectively 42 in. and 50 in. Assuming the correctness of the previously found alternating stresses of ± 10.57 tons per sq.in. for the failure, which occurred after 24 hours' heavy service immediately after previous annealing, the relative movements of the ends of the pipe should be 0.27 in. Seeing that the estimated alternating stresses during the previous ten years' running were only ± 5.27 tons per sq.in., the relative movements of the pipe ends during this longer period do not seem to have exceeded ± 0.14 in.

Report No. 1954 deals with an L-bend of sheet-copper 4.92 in. external diameter. According to the sketch, L and R seem to be respectively 93 in. and 32 in. Assuming the correctness of the previously found alternating stresses of ± 13.85 tons per sq.in. for the new pipe, which failed during a run of four hours in heavy weather, the relative movements of the ends of the pipe should be ± 0.23 in. For the old pipe, which failed after eight years' running under stresses of ± 5.33 tons per sq.in., the relative movements should be ± 0.09 in.

TABLE V. PROFESSOR BAUTLIN'S TEST RESULTS

Difference between two Successive Thrusts in Pounds

Estimated and Observed Displacement of Flange C. Inches

	220 Est.	220 Obs.	440 Est.	440 Obs.	660 Est.	660 Obs.	880 Est.	880 Obs.	1325 Est.	1325 Obs.	1980 Est.	1980 Obs.	2420 Est.	2420 Obs.
A..					0 30	0 68			0 60	1 37	0 90	2 16	1.10	2.96
B.	0 84	0 69	1 67	1 42								.	....	....
C..			0 06	0 10			0 12	0 22	0 17	0 33			....	..
D	.			....	0 19	0 24			.	.			....	
E					0 30	0 33					.	. . .	....	.

The elastic limit was reached with pipe A with a thrust of 1809 lb

Report No. 1355 deals with an L-bend of solid-drawn copper 5.19 in. external diameter. According to the sketch, L and R seem to be respectively 70 in. and 100 in. long. Assuming the correctness of the previously found alternating stresses of ± 5.62 tons per sq.in., the relative movements of the ends of the pipe should be ± 0.39 in.

Report No. 1543 deals with a U-bend of solid-drawn copper 4.94 in. external diameter. Judging by the sketch, L and R seem to be respectively 16 in. and 46 in. long. Assuming the correctness of the previously found alternating stresses of ± 5.52 tons per sq.in., the relative movement of the ends of the pipe should be ± 0.26 in.

Report No. 2021 deals with an L-bend of solid-drawn copper 5.5 in. external diameter and 0.25 in. thick. According to the sketch, L and R seem to be respectively 68 in. and 42 in. Assuming the correctness of the previously found stresses of ± 5.1 tons per sq.in., the relative movements of the ends of the pipe should be ± 0.17 in.

TABLE VI. ESTIMATED INTENSITIES OF FATIGUE STRESSES AND THE RELATIVE MOVEMENTS OF THE ENDS OF THE FRACTURED PIPES

Report Number	Assumed Number of Vibrations	Estimated Fatigue Stresses, Tons per Sq.In.	Estimated Fatigue Movements, In.
Failures Due to Vibrations of the Engines			
958 (1)	15,000,000	± 6 02	± 0.38
958 (2)	31,000,000	± 5 74	± 0.25
1049 (1)	40,000,000	± 5.65	± 0 049
1049 (2)	15,000,000	± 6.02	± 0.051
1181 (1)	150,000,000	± 5.27	± 0.14
1181 (2)	86,000	± 10 57	± 0.27
1954 (1)	120,000,000	± 5.33	± 0.09
1954 (2)	14,000	± 13.85	± 0.23
Failures Due to Loose Engine Seatings			
1355	44,000,000	± 5.62	± 0.39
1543	60,000,000	± 5.52	± 0.26
2021	45,000,000	± 5 61	± 0 17

*Zeitschrift des Vereins Deutscher Ingenieure, 1910, Vol. 54, page 43. Also Mitteilungen über Forschungsarbeiten des Vereins Deutscher Ingenieure, Vol. 96.

These and the previous estimates are summarized in Table VI. They are all based on the empirical formula which correlates the fatigue stresses for copper and the number of their repetitions up to the point of failure. The experiments on which it is based are comparatively few, and more comprehensive ones will shortly be carried out on a new fatigue-testing machine which is nearing completion; but seeing that the results of fatigue tests with mild steel are consistent, the intended further experiments on copper will probably merely confirm those already obtained.

Assuming the correctness of the empirical formula, then, judging by the estimates contained in Table VI, relative movements between engines and boilers of ±0.38 in. (see No. 958) or more should be allowed for. These were associated with fatigue stresses of ± 6.02 tons per sq.in., which exceed the fatigue limit of ± 4.3 by 1.7 tons per sq.in. If these relative movements of ± 0.38 in. had not exceeded ± 0.27 in., the pipe would not have failed. Had the pipe been made of steel it would also not have failed, for although its modulus of elasticity is 13,000, as against 8300 tons per sq.in. for copper, the respective fatigue limits are 10.3 and 4.3 tons per sq.in., and the maximum relative movement to which such a steel pipe would have submitted without injury would have been ± 0.43 in. Conversely, if a steel pipe of the above dimensions were replaced by a copper one and the relative movements of its ends were maintained at ± 0.43 in., then the fatigue stresses in the copper pipe would be ± 6.77 tons per sq.in., or ± 2.47 tons above the fatigue limit of ± 4.3 tons, and the copper pipe would fail after 3,600,000 repetitions. This means that if any copper pipe were to fail after experiencing 3,600,000 stress cycles, which corresponds to 42 days' continuous running of the engines at 60 revolutions per minute, and if it were to be replaced by a steel pipe, this would last forever, and as most of the pipes dealt with in the Board of Trade reports did last longer than 42 days, the number of explosions would have been correspondingly reduced if steel pipes had been used instead of copper.

But—and this is the point which should not be overlooked—it is highly probable that the cast-iron valves to which these steel pipes would have to be attached would have fractured at an early date, because the resisting moments of steel pipes are 1.56 times greater than those of copper pipes of the same dimensions, and even copper pipes are occasionally strong enough to fracture the cast-iron valves to which they are attached, as is evident from the following Board of Trade reports:

No. 389. A copper pipe with fairly large bends broke the neck of the valve-chest to which it was attached.

No. 556. The thrust on an expansion-gland acting at the end of a copper pipe as a lever broke the neck of the valve-chest to which it was attached.

No. 971. A copper pipe attached to the end of a combined expansion gland, stop valve and throttle-valve casing broke the latter.

No. 1072. A copper pipe broke the cast-iron neck of a steam chest to which it was attached. The other end of the pipe formed part of an expansion gland which was attached to the engine whose lateral motion was the cause of the fracture.

No. 1177. A copper U-bend between the boiler and its engine acting on the end of a throttle-valve casing broke it.

No. 1572. The thrust of an expansion gland acting at the end of a copper bend broke the valve-casing to which it was attached.

In the following cases the pipes were of wrought iron:

No. 1230. A straight wrought-iron pipe between an expansion gland on the engine and a short cast-iron bend on the boiler stop-valve broke the neck of the latter.

No. 1404. A straight iron pipe which ended in an expansion joint broke the neck of the valve-casing to which it was attached.

The following rather unusual failures may be due to bad material, but seeing that they occurred both with sheet-copper, solid-drawn and electro-deposited pipes it is not unlikely that they were due to fatigue stresses. However, as all these cracks are along the neutral line of the copper bends where there are no bending stresses, but where the shearing-fatigue stresses are maximum, it is not unlikely that these alternating shearing stresses were relatively more intense than the bending stresses near the flanges. It should also be remembered that the fatigue limit for shearing stresses is only ± 2.5 tons per sq.in.

No. 1231 deals with a sharp bend of sheet copper 3.55 in. external diameter which cracked near the brazing line, which is also the neutral line of the bend. The bend was eight years old when it failed.

No. 1262 deals with a bend of sheet copper 10.2 in. external diameter which cracked near the brazing line like the above-mentioned bend. This pipe failed after sixteen months' work.

No. 1662 deals with a bend of solid-drawn copper 6½ in. external diameter which failed along the neutral line after three years' work, when it was repaired and annealed, but it failed again after seven years.

No. 1839 deals with an expansion bend of solid-drawn copper 5.42 in. external diameter which failed along the neutral line after nine years' work. Locally the tenacity was reduced to 5.6 tons with no elongation.

No. 1882 deals with a bend of solid-drawn copper 5.2 in. external diameter which failed along the neutral line after three years' work. It had probably been damaged locally while being repaired. Locally the tenacity was reduced to 7 tons with 1.5 per cent. elongation.

No. 2110 deals with an expansion bend of solid-drawn copper 5.4 in. diameter which failed along the neutral line after four and one-half years' work.

No. 2140 deals with an expansion bend of solid-drawn copper 6½ in. external diameter which failed along the neutral line after six years' work.

No. 986 deals with a bend of electro-deposited copper 3⅞ in. external diameter which failed along the neutral line after three years' work.

No. 1383 deals with a bend of electro-deposited copper 4.8 in. in external diameter which failed along the neutral line after seven years' work, close to a repair sleeve which had been brazed on three months before the explosion.

No. 1736 deals with a bend of electro-deposited copper 3.8 in. in diameter which failed after one year's work. The tenacity was locally reduced to 12.5 tons with 5 and 8 per cent. elongation.

No. 1770 deals with a bend of electro-deposited copper 5.4 in. in external diameter which failed after two years' work. The tenacity was reduced from about 13.5 tons with 45 per cent. elongation to between 9 and 10 tons with 5 to 7 per cent. elongation.

No. 2163 deals with an expansion bend of electro-deposited copper 6 in. external diameter which failed along the neutral line after six years' work.

If, as seems probable, the above 12 failures (about 8 per cent. of the total) were due to sheer fatigue stresses, which are severest along the neutral lines of beams, they would indicate that the bends had been subjected to more complicated forces than have been assumed when dealing with the other failures, but in the absence of any details about the relative movements of the engines and boilers it is fruitless to venture on any estimates, except to say that the formula for torsion fatigue stresses should be applied to these cases and that the stresses which are due to the internal steam pressures should not under any circumstances be overlooked.

While studying those Board of Trade reports which seemed to have a bearing on the present question it was noticed that many copper pipes had failed shortly after being annealed, although until then they had worked satisfactorily for years. This experience would suggest either that annealing does not remove the effect of fatigue stresses or that, if carried out injudiciously, it changes tough copper into a brittle material. In the following list of reported cases the numbers in parentheses denote the periods in months which elapsed between the dates of annealing and of failure:

Pipes of Brazed Sheet Copper.—Nos. 1922 (4), 1210 (5), 1021 (6), 2105 (17), 1011 (19), 1443 (23).

Solid-Drawn Copper Pipes—Nos. 1839 (½), 1926 (2), 1709 (5), 1327 (6), 1327 (8), 1993 (9), 1187 (10), 2003 (21), 2110 (36), 1898 (48).

Electro-Deposited Copper Pipes—Nos. 1164 (3), 1501 (12), 970 (12), 1610 (19).

The average life of a copper pipe after being annealed seems to be about one year for each one of the above three groups, but as already suggested these cases do not prove that annealing is or is not a remedy for fatigued copper. This experience as regards copper does not apply to steel pipes.

As a safeguard against fatigue stresses in steam-pipes expansion glands are sometimes fitted, but they are not always applied where wanted; they sometimes stick fast, and if badly designed the pipes blow out of their sockets.

This latter class of accidents is illustrated in reports Nos. 779, 1702, 2246.

Pipes which stuck fast in their sockets and did not take up the movements are to be found in reports Nos. 283, 1296, 1404, 1666, the last being a doubtful case.

In the following cases the thrusts of the pipes in the glands acting on long bends fractured these near the roots or the glands had stuck fast and the fractures were due to fatigue: Nos. 556, 1113, 1187, 1207, 1230, 1343, 1489, 1572, 1583, 1605, 1609, 1852, 1916, 1978. These are mostly marine cases.

In the following cases the expansion glands neither prevented the pipes from fracturing nor did they cause the fractures: Nos. 169, 584, 971, 1011, 1035, 1056, 1072, 1109, 1172, 1185, 1214, 1264, 1398, 1461, 1515, 1537, 1556, 1747, 1771, 1899, 2006. About half of these cases occurred on steamers.

The New York Central Wins the Harriman Medal

At the annual meeting of the American Museum of Safety held in the United Engineering Societies Building, 29 West Thirty-ninth St., New York City, Feb. 10, 1915, the E. H. Harriman memorial gold medal for the American steam railway making the best record in accident prevention and industrial hygiene affecting the public and its own personnel during the year ending June 30, 1914, was awarded to the New York Central R.R. The award was made to this road for its record on the New York Central & Hudson River R.R. prior to its consolidation with the Lake Shore. The medal was offered by Mrs. E. H. Harriman to be awarded through the American Museum of Safety. The committee of award consisted of: Arthur Williams, president American Museum of Safety; Samuel O. Dunn, editor "Railway Age Gazette"; Prof. Alexander C. Humphreys, president Stevens Institute; Hon. Chas. P. Neill, former U. S. Commissioner of Labor; and Hon. Edgar E. Clarke, member Interstate Commerce Commission. The medal was received on behalf of the railroad by Alfred H. Smith, president. The silver medal was awarded to the operating department, and the bronze medal to Dennis Joseph Cassin, who had been an engineer on the Central since 1867. He had never had an accident.

The Overloading of Safety Valves

The formal Board of Trade inquiry in connection with the terrible boiler explosion that occurred at the Thornhill Iron & Steel Works, Dewsbury, on Aug. 10 last, causing the death of eight men, and more or less serious injury to 17 others, provides a lesson which it is to be hoped will be taken to heart by every boiler attendant in the country, as to the criminal folly of interfering with the action of safety valves. The facts of the case were very simple. The boiler, which was one of eight at the works, all coupled together, was of the Rastrick type, heated by the flames from iron furnaces, and was normally worked at 55 lb. per sq.in.

The works were closed from July 31 to Aug. 10, and when the boilers were started the engineer noticed steam blowing off at the safety valves on No. 4 boiler, and without examining the stop valve or the pressure gage he assumed that the escape of steam was due to some defect of the safety valves—of which there were two loaded by levers and weights—and tried to correct it, first by sliding the weights to the end of the lever, and this proving insufficient, by adding a weight of 50 lb., which, being still inadequate to prevent the escape of steam, was supplemented with another 63 lb. As a matter of fact, which was proved after the explosion, the stop valve was shut and the boiler thus isolated from the others to which it was supposed to be connected, and the escape of steam was due to the steady rise of pressure in the boiler, in which steam was being generated without any outlet, and was being bottled up by the extra load on the valves. There could, of course, be only one end to this incredible madness, and that was reached about two or three hours after the fire was started, when the bursting pressure, which would probably be getting near 200 lb., was reached and instantly converted the whole works into a heap of ruins, killing or injuring nearly everybody in the place.

How anyone with a knowledge of boilers could be guilty of such recklessness as to overload safety valves in this deliberate way, without seeing what the pressure was or making sure that any steam generated had at least access to the safety valves of the other boilers, surpasses belief, and we can well understand the Board of Trade Commissioner, when he heard the frank admissions of negligence at the inquiry, "wondering whether or not he was in a lunatic asylum." There were, of course, no technical questions involved in the explosion, for whatever type of boiler had been used the explosion would inevitably have occurred. The inquiry resolved itself into one of fixing responsibility for the disaster, and in view of the engineer's admissions as to the personal part he played there could be no doubt where it lay. The only excuse he could offer was that he thought the stop valve was open, as it was left open when the boilers were laid off on July 31, but he took no steps to verify this assumption or even to look at the pressure gage before he proceeded to hang on weights practically equivalent to a man sitting on the end of the levers. Who shut the stop valve it was impossible to find out, and as regards responsibility little matters, for the most ordinary precaution should have suggested to the engineer that freedom for escape of the steam generated in the boiler should be provided in some way before such "an act of madness" as the overloading of the safety valves was resorted to.

The question remains, how can the consequences of similar crass ignorance be guarded against in the future? The ordinary lever type of safety valve does, it must be admitted, permit of being easily tampered with and overloaded. Of course, whatever type of safety valve is used there is little to protect it from interference, from reckless ignorance or malignant ingenuity, though a locked-up valve which no one could touch would protect such a fitting to some extent from the former risk, and as the Commissioners, in their judgment, which saddled the responsibility for the explosion entirely on the engineer and the boiler attendant who assisted him, emphasize the necessity of valves which can be protected from any interference being adopted, it is possible we may before long see some Board of Trade regulation of this kind imposed on all steam users.—"The Mechanical Engineer," Manchester, Eng.

Elimination of Smelter Smoke

With the idea of bringing about a better understanding between the metallurgical industry and agriculture as to the troublesome smoke problem at smelting and ore-roasting plants, the United States Bureau of Mines has just issued "Bulletin 84."* Copies may be obtained by addressing the Director, at Washington, D. C. Owners of smelting plants are making every effort to devise ways and means to do away with possible damage and annoyance from great volumes of smelter smoke, comparatively rich in sulphur dioxide and other injurious constituents.

It has been customary to discharge the smelter smoke by very tall chimneys, on the assumption that if the noxious gases are discharged at considerable height they will have opportunity to diffuse more thoroughly and thus become so diluted as to be comparatively harmless, but the efficiency of this method is now being questioned. There is reason to believe that the use of high stacks increases the area to damage, whereas low stacks may intensify the damage but concentrate it within a small area. Probably high chimneys do not serve their purpose as well as was anticipated, and the better method may be to dilute the smelter smoke and discharge it from a number of low stacks.

Massachusetts Electric Rates Discussed

A battle royal on the subject of electric rates was started on Feb. 5 before the Committee on Public Lighting of the Massachusetts Legislature, which is considering House Bill No. 346, relative to the prices to be charged for electrical energy by central stations. The bill was brought before the committee on petition of the New England Power League, an organization formed about three years ago by manufacturers, business houses, engineers of isolated plants and others interested in the economical use of power. Ernest Stevens, chief engineer of Riverbank Court Hotel, Cambridge, Mass., led the advocates of the bill, which provides that no public-service corporation shall be allowed to sell electricity at less than 5 per cent. above the cost of production and distribution, that the maximum price charged for electricity shall not exceed 25 per cent. over and above the cost of production and distribution, and that the Board of Gas and Electric Light Commissioners shall have power to determine such costs after a thorough examination of all books and properties belonging to such companies.

The principal evidence on behalf of the bill was offered by Thos. W. Byrne, consulting engineer, of Boston, who contended that 90 per cent. of the users of electricity purchase energy at the maximum price and that these small users are charged at least five times as much per kilowatt-hour as the large consumers of power, who easily buy electricity at two cents or less per kilowatt-hour. The speaker urged that the central-station policy is to "charge what the traffic will bear," and said that the National Electric Light Association at its Philadelphia convention in 1914 had gone on record in support of the principle that the value of central-station service was in a large measure determined by the ability of the consumer to install a private plant.

Mr. Byrne contended that the basis of rates should be a fair return on the investment and advocated a valuation of all existing electric-lighting properties in the state by the Gas and Electric Light Commission, for the purpose of checking up the reasonableness of the rates now in force. He pointed out that in the decision of the board in the Worcester street-lighting rate case, the commission had called attention to the power of the company to dictate prices to the small consumer. Members of the Power League feel that present

*The suggestions contained in this bulletin may also be applicable to the power-plant smoke problem.—EDITOR.

central-station rates in various cities of the state are discriminatory, and favor requiring the commission to set forth its views upon the price differences, if any, which should be allowed between lighting and power rates, and between residential and other users, as related to the quantity of energy purchased and as affected by long and short periods of use.

Available Water Power in United States

According to recently compiled figures made by the U. S. Geological Survey, the total available water power in the United States amounts to about 200,000,000 hp., of which only 6,000,000 is developed. The total available is estimated on the basis of practicable maximum storage of waters possible by the construction of dams and reservoirs. Without storage, the available water power is placed at only 61,678,000 hp., of which the present development is about one-tenth. The water powers as listed by the Geological Survey are distributed in the several states and sections of the country as follows:

North Atlantic States:	
Maine	971,000
New Hampshire	295,000
Vermont	206,000
Massachusetts	273,000
Rhode Island	16,000
Connecticut	164,000
New York	2,037,000
New Jersey	127,000
Pennsylvania	821,000
	4,910,000
South Atlantic States:	
Delaware	13,000
Maryland	146,000
Dist. of Columbia	13,000
Virginia	1,044,000
West Virginia	1,261,000
North Carolina	1,050,000
South Carolina	812,000
Georgia	752,000
Florida	16,000
	5,107,000
North Central States:	
Ohio	213,000
Indiana	141,000
Illinois	414,000
Michigan	352,000
Wisconsin	804,000
Minnesota	593,000
Iowa	458,000
Missouri	195,000
North Dakota	248,000
South Dakota	90,000
Nebraska	439,000
Kansas	323,000
	4,270,000
South Central States:	
Kentucky	236,000
Tennessee	913,000
Alabama	1,132,000
Mississippi	75,000
Louisiana	2,000
Arkansas	73,000
Oklahoma	250,000
Texas	661,000
	3,342,000
Western States:	
Montana	5.197,000
Idaho	3,080,000
Wyoming	1,566,000
Colorado	2,036,000
New Mexico	527,000
Arizona	2,038,000
Utah	1,581,000
Nevada	331,000
Washington	10,376,000
Oregon	7,935,000
California	9,382,000
	44,049,000
Summary of States:	
North Atlantic	4,910,000
South Atlantic	5,107,000
North Central	4,270,000
South Central	3,342,000
Western	44,049,000
Grand total	61,678,000

Fatal Sawmill-Boiler Explosion

On Jan. 20 at about 10 a.m. the boiler of a portable sawmill near Beverly, Mo., exploded, killing two and seriously injuring another. A father and his four sons were operating the sawmill on the lowlands of the Missouri River. The engine had been stopped to make some adjustment to the saw. Two of the boys had just left for home near-by, and the other two, aged 7 and 18 years, respectively, were in front of the boiler.

The explosion killed the two boys instantly, disfiguring them almost beyond recognition. The father was found in the underbrush near-by, severely scalded and unconscious. It is believed that he will recover. The boiler was blown through a shed and across a boggy creek for a distance of about 300 ft. from its foundation, striking the ground twice before it finally stopped.

The boiler was of the locomotive type 11½ ft. long with firebox 30x48 in. The front part of the crown and sides of firebox were forced down nearly to the bottom of the furnace. This was the only part that gave way, the tubes, shell and outer firebox sheets remaining intact. The firesheets and stay-bolt ends were badly pitted and eaten away by corrosion, so that the stay-bolts had very little hold. At some parts of the blowoff opening the plate was less than one-sixteenth of an inch thick.

The safety valve and steam gage had not been found up to the time of writing this, as the ground was covered with several inches of snow that had fallen the following night. The inside of the boiler seemed clean. The water column and connections were clear so that it showed the true water level. The injured man claims that there was plenty of water in the boiler just before it exploded.

The owner bought the second-hand boiler about a year ago, when he was told not to carry over 80-lb. pressure. From the appearance of the boiler it ought not to have been used and should have been in the scrap pile.

This is the third explosion of old boilers that has occurred in this vicinity in the last three years, which goes to show the great need of state boiler inspection and engineers' license laws.

Recent Court Decisions

Digested by A. L. H. STREET

Assumption of Risk by Employee—An employee of a power company who was directed to make repairs on a dam while water and ice were running over it assumed the risk of being swept from the dam by the force of the stream, according to a late decision of the Maine Supreme Judicial Court, announced in the case of Monk vs. Bangor Power Co., 92 "Atlantic Reporter," 617.

Negligent Operation of Boilers—When negligence of an engineer leads another employee of a common employer to believe that an explosion has occurred or is imminent, and such other employee is injured in attempting to avoid the danger apprehended, the employer may be held responsible in damages, unless the "fellow-servant rule" happens to be applicable. This statement is warranted by a late decision of the Indiana Supreme Court, in the case of Stringer vs. Vandalia R.R. Co. (106 "Northeastern Reporter," 865), wherein defendant was held liable for injuries sustained by a brakeman leaping from a locomotive after the engineer had permitted the crown-sheet of the boiler to run dry and then suddenly turned water on it, causing the crown-sheet to fall, under circumstances which naturally tended to make the brakeman suppose that an explosion had either occurred or was imminent.

PERSONALS

Edward P. Burch, E. E., has opened an office as consulting engineer, in the Dime Bank Building at Detroit. General practice is contemplated, with specialization in mechanical and railway work and in property valuations.

Dr. Robert Grimshaw, one of the early editors of "Power" and the only living charter member of James Watt Association No. 7, N. A. S. E., of New York, attended the Feb. 13 meeting of that association. Dr. Grimshaw is on a brief visit to the United States, having lived for many years in Germany.

Guy E. Marion, secretary-treasurer of the Special Libraries Association, has severed his connection with Arthur D. Little, Inc., the well known chemists, engineers and managers, of Boston, where he has been located for the last five years in charge of their information department. He has offices in the Tremont Building, Boston, with W. H. Manning, landscape designer.

William W. Cole, of 43 Exchange Place, and Arthur S. Ives and Rolland A. Davidson, composing the firm of Ives & Davidson, of 84 William St., announce the formation of a partnership for the general practice of engineering, under the firm name of Cole, Ives & Davidson, with offices at 61 Broadway, New York. Especial attention will be given to investigations and reports for financial interests, inventories and valuations of public utility or industrial properties and design, installation or management of power plants of all descriptions.

Walter N. Cargill has been appointed superintendent of power and lines of the Rhode Island Co., with headquarters at Providence, and will take up his new work on Apr. 1. For eight years he was in charge of engineering, construction and operation in the one substation and 10 power stations of the lines north of Boston now comprising the northern portion of the Bay State Street Ry. He resigned in 1911 to join the engineering staff of the Stone & Webster Engineering Corporation, where he has since been occupied with investigations, appraisals and problems of a mechanical character in connection with the generating plants designed, examined or operated by the organization.

Lyndon F. Wilson, vice-president of the Railway List Co., Chicago, has resigned to become vice-president of the Bird-Archer Co., New York, manufacturers of boiler compounds, effective Apr. 1, 1915. He was born at Rush Lake, Wis., Nov. 4, 1883. He was educated at Ripon College, Lawrence University and the University of Wisconsin, and after some general machine-shop and power-plant experience, became an engineer in the service of the United States Government (Department of the Interior), passing examinations in steam, electricity, and heating and ventilating. After one year in this service, he joined the engineering department of the Western Electric Co. and was so engaged until the fall of 1908, when he became mechanical department editor of the "Railway Review," Chicago. In the spring of 1909 he became editor of the "Railway Master Mechanic" and was subsequently given editorial charge of "Railway Engineering," both being published by the Railway List Co. He was promoted to the vice-presidency of this company in the summer of 1913. After Apr. 1, Mr. Wilson will be located in the Chicago office of the Bird-Archer Co.

NEW PUBLICATIONS

COAL SAMPLING AND ANALYSIS—Technical Paper 76, of the Bureau of Mines, Department of the Interior, is a collection of notes on the sampling and analysis of coal, by A. C. Fieldner. Copies may be had free by applying to the Director of the Bureau of Mines, Washington, D. C.

GEORGE WESTINGHOUSE—To those who did not know him personally, a reading of the Tribute, by Arthur Warren, will give an idea of the elements of his greatness and success, and of the fullness of the life which he lived. Mr. Warren's association with the master was intimate and of long duration, and his Tribute is an evident labor of love.

PENNSYLVANIA RAILROAD has issued a booklet, for distribution at the Panama-Pacific Exposition, describing its activities and exhibit at the Fair and containing a map of the entire system, which, it is claimed, serves 52 per cent. of the population of the United States. It also contains illustrations of the proposed Union Station in Chicago, the main span of the East River bridge, and a model of New York City. A photograph of the last is also reproduced in colors on the cover page. This model shows the city just as if one were looking at it from an aëroplane. It reproduces faithfully not only the main physical features of Manhattan Island and the surrounding country and water courses, but the prominent buildings, the streets, the bridges spanning East River, the parks, and the squares.

CENTRIFUGAL PUMPS—What is probably the most complete commercial publication devoted solely to centrifugal pumps is being distributed by the De Laval Steam Turbine Co., of Trenton, N. J. This book of 298 pages contains over 300 illustrations, including centrifugal pumps for all capacities and heads and for motor and steam-turbine drives, diagrams showing the "characteristics" of such pumps and explaining the relations between impeller-blade angles and characteristics, interior views and views of parts showing the construction, views showing the method of manufacture by the use of limit gages and methods of testing, installations of pumps for various services, also numerous illustrations of the DeLaval reducing gear employed to allow electric motors, water turbines, steam engines and steam turbines to operate at the most economical speed when driving a centrifugal pump. The text matter is divided into chapters under such headings as, "The Introduction of the Centrifugal Pump and the Work for Which It is Adapted"; "Features to be Considered in Selecting Centrifugal Pumping Equipment"; "The Use of the Characteristic Curve"; "Methods of Testing Centrifugal Pumps"; "System of Manufacture for the Production of Interchangeable Parts"; "Details of Design and Construction of Single-stage and Multi-stage Pumps"; "The Speed Question, Particularly Relating to Steam Turbine-Driven Centrifugal Pumps"; "Helical Speed-Reducing Gears"; "Motor and Belt Drives"; "High-Duty Steam Turbine-Driven Pumps as Compared with Reciprocating Pumping Engines for Water-Works Service"; "The Adaptation of Pumps for Circulating Condenser Water, Feeding Boilers and other Steam Power-Plant Service"; "Drainage and Irrigation Pumps"; "Hydraulic Pressure and Elevator Pumps"; "Pumps for Marine Uses, Mining Service, Fire Service and Hot Water and Brine Circulation", etc. Tables and charts are given for determining the resistance of pipes and the relation between heads and spouting velocities. The investigation of the pumping problem, together with drawing up of specifications for centrifugal pumps, are also treated at some length. The chapters on "Pump Characteristics" will prove more valuable to the pump user than many of the more technical treatises. The chapter on "Water Works Pumps," showing that under many conditions the centrifugal pump can handle water at a cost 20 to 40 per cent. lower than it can be handled by reciprocating pumps, because of the lower fixed charges, it is thought will be a revelation to many who have not recently given this matter consideration.

BOOKS RECEIVED

VALVE GEARS. By Charles H. Fessenden. McGraw-Hill Book Co., New York. Cloth; 170 pages; 6x9¼ in.; 171 illustrations. Price $2.

THE "MECHANICAL WORLD" POCKET DIARY AND YEAR BOOK for 1915. The Norman Remington Co., Baltimore, Md. Cloth; 439 pages, 4x6¼ in.; illustrated; tables. Price 50 cents.

THE "MECHANICAL WORLD" ELECTRICAL POCKET BOOK for 1915. The Norman Remington Co., Baltimore, Md. Cloth; 303 pages, 4x6¼ in.; illustrated; tables. Price 50 cents.

THE DESIGN OF STEAM BOILERS AND PRESSURE VESSELS. By George B. Haven and George W. Swett. John Wiley & Sons, New York. Cloth; 416 pages, 6x9¼ in.; 197 illustrations, including several plates; tables. Price $2.50.

TRADE CATALOGS

D. G. C. Trap & Valve Co., Inc., Fuller Building, New York. Folder. Brown steam trap. Illustrated.

De Laval Steam Turbine Co., Trenton, N. J. Catalog B. Centrifugal pumps. Illustrated, 298 pp., 6x9 in.

Pelton Water Wheel Co., 90 West St., New York. Bulletin No. 8. Water wheels. Illustrated, 64 pp., 6x9 in.

The Terry Steam Turbine Co., Hartford, Conn. Bulletin No. 19. Centrifugal pumps. Illustrated, 64 pp., 6x9 in.

L. J. Wing Mfg. Co., 352-262 West 13th St., New York. Bulletin No. 27. Turbine Blowers, Type E. Illustrated, 20 pp., 6x9 in.

Gas Engine & Power Co. and Chas. L. Seabury & Co., Morris Heights, N. Y. Catalog. Seabury water tube boiler. Illustrated, 46 pp., 6x9 in.

Schutte & Koerting Co., 12th and Thompson Sts., Philadelphia, Penn. Sectional Catalog. Heat transmission apparatus. Illustrated, 8½x11 in.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale**, 5 cents a word, minimum charge, $1.00 an insertion.

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Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

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POSITIONS OPEN

AN EXPERIENCED CENTRAL-STATION ENGINEER required to take charge of a 4000-kw. steam and electric plant, containing turbine- and engine-driven A.C. and D.C. generators, water-tube boilers and stokers; must be particularly well versed in steam economy; plant located 50 miles from Chicago; salary $1500 per year; only a thoroughly competent and well recommended man need apply. P. 430, Power, Chicago.

Civil-Service Opportunities

Competitive examinations for the civil-service positions named below will be held on or up to the dates given. For detailed information, write the addresses specified.

ELECTRICAL ENGINEER (male); $200-$300 per month; for vacancy in the Accounting and Engineering Dept. of the Illinois Public Utilities Commission. Write to the State Civil Service Commission, Springfield, Ill.

DRAFTSMAN (male); $75-$100 per month; examination Mar. 6; for vacancy in the Accounting and Engineering Dept. of the Illinois Public Utilities Commission. Write to the State Civil Service Commission, Springfield, Ill.

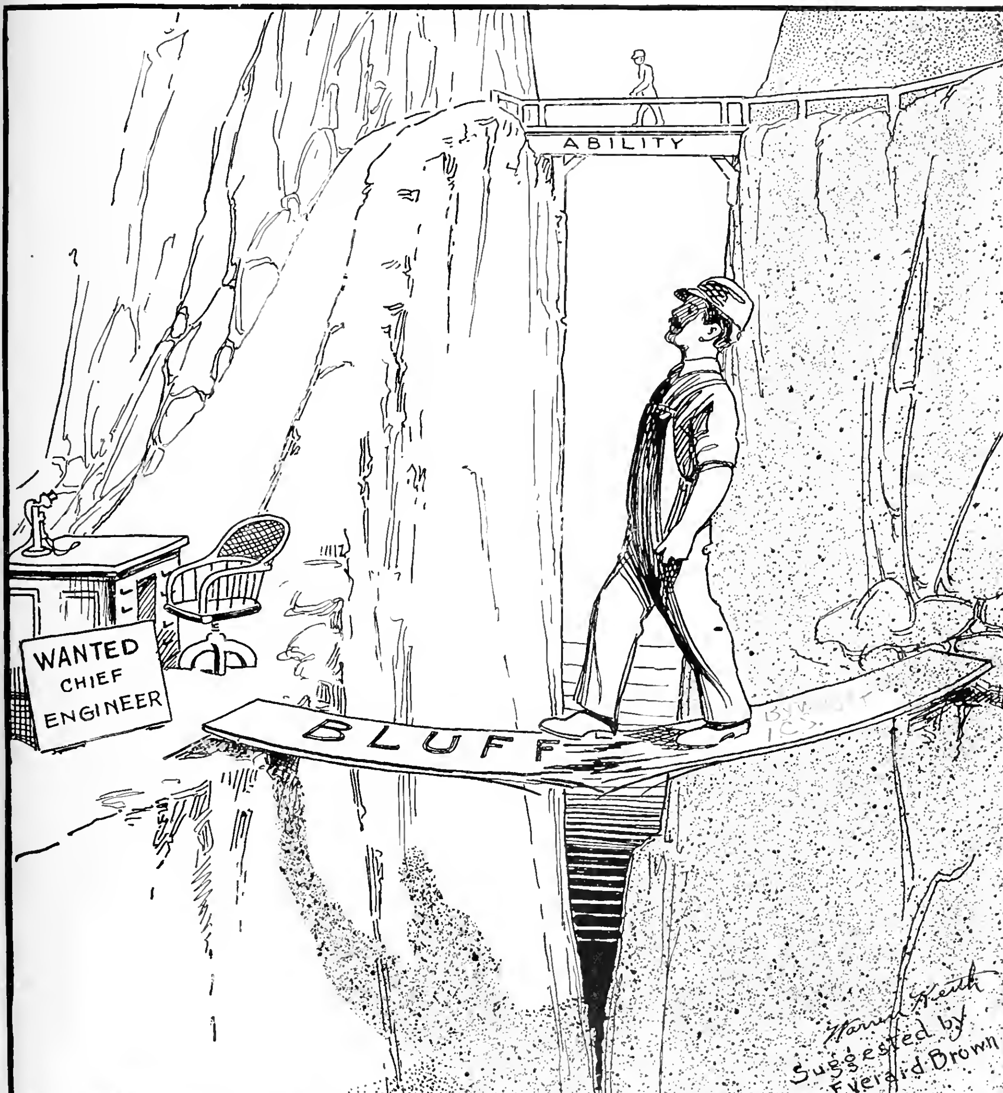
GAS ENGINEER (male; $250-$333.33 per month; for vacancy in the Accounting and Engineering Dept. of the Illinois Public Utilities Commission. Write to the State Civil Service Commission, Springfield, Ill.

POWER GENERATION AND TRANSMISSION

POWER

ONE OF THE HILL ENGINEERING WEEKLIES

Vol. 41 NEW YORK, MARCH 2, 1915 No. 9



THE LONGER WAY IS SAFER

Fairview Sewage-Pumping Station

By Thomas Wilson

SYNOPSIS—An attractive plant equipped with angle-compound-centrifugal pumping units. Its capacity is 150,000,000 gal. in twenty-four hours. The efficiency of the pumps is 70 per cent. The equipment cost $118,000.

One of Detroit's show plants, put in commission in October, 1912, is the Fairview sewage-pumping station. The machinery is neatly arranged and kept in excellent condition. The boilers wear a "dress suit" of white enamel brick, which with metal trimmings at the corners and across the front add to the general attractiveness of the boiler room.

The building itself is of the classic style of architecture to harmonize with the surroundings, as eventually the plant will be in a residence district. Buff Roman brick walls trimmed with terra cotta are reinforced by a steel frame. Concrete slabs covered by red tile form the roof. Within, a wainscoting of white glazed tile, walls of gray face-brick, a floor paved with red tile, steel doors, electroplated railings and Fenestra steel sash lend an attractive appearance.

The plant is located at the foot of Parkview Ave., near Waterworks Park, and 234 ft. back from the harbor line. It was designed to raise domestic sewage and storm water from a 9-ft. sewer draining 3500 acres of residence property and discharge it into the Detroit River. The sewage enters a screen chamber, shown to the left of the main building in Fig. 2, and passes on to a water gallery formed between the building foundation and a division wall in the basement. This well is 137 ft. long, 40 ft. deep and 9 ft. wide. As shown in Fig. 1, the sewage flows by gravity into the suction of the pumps and through cast-iron pipes is raised 36 ft. to brick outlets discharging into the river. Hydraulically operated gate valves are placed in the discharge lines.

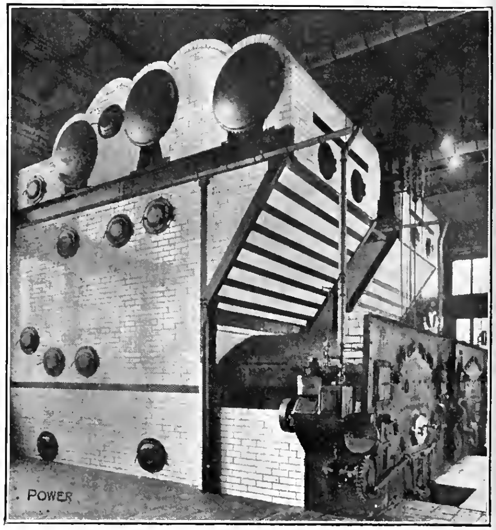


Fig. 3. Boilers in Their Dress Suits of White Tile

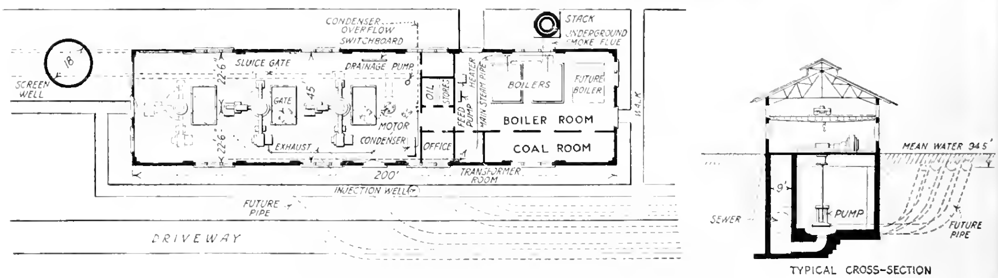


Fig. 1. Plan and Vertical Section through Station

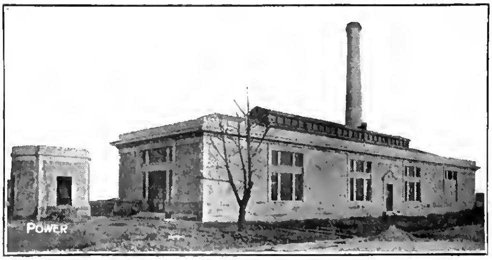


Fig. 2. Fairview Sewage-Pumping Station

The pumping equipment consists of two steam-driven units, each having a capacity of 100 cu.ft. per sec., and a motor-driven pump capable of delivering 30 cu.ft. per sec. Provision has been made in the design of the plant for the future installation of a third steam unit. The pumps are of centrifugal type set horizontally with vertical shafts and half imbedded in the concrete of the basement floor. Two are 42-in. units and the third is a 24-in. pump, the suction connections to the water gallery being 54 and 36 in. diameter, respectively. The large pumps are driven by variable-speed angle-compound engines, 18 and 36 by 36 in., which, at 150 lb. gage pressure, 18 lb. receiver pressure, a vacuum of 25 in. and a speed of 100 r.p.m., indicate 500 hp. The steam supply pipe is 6 in. diameter, the high-pressure exhaust 10 in. and the low-pressure exhaust 12 in. All piping except the loop to the throttle is underneath the floor. Connection between engine and pump is effected by a 9½-in. vertical shaft 40 ft. long. Near the center of its length a bronze and cast-iron thrust bearing carries the weight of the shaft. The bearing runs in oil and is provided with a water jacket which may be used if needed on long continuous runs. Ordinarily, the oil keeps the bearing cool.

PRINCIPAL EQUIPMENT OF FAIRVIEW SEWAGE PUMPING STATION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Angle, compound	18 and 36 by 36-in.	Drive cent. pumps	Steam press. 150 lb., vacuum 25 in., 100 r.p.m.	Wisconsin Engine Co.
2	Pumps	Centrifugal	42-in.	Main units	Capacity 100 sec.-ft. against 36 ft. head	Camden Iron Works
1	Pump	Centrifugal	24-in.	Main unit	Driven by 150 hp. Westinghouse motor, 360 r.p.m.	Camden Iron Works
1	Condenser	Barometric	16-in.	Serving engines	River injection water, vacuum, 25-in.	Camden Iron Works
1	Pump	Centrifugal	6-in. discharge	Water to condenser	Driven at 350 r.p.m. by 8x10-in. Shepherd double engine	Camden Iron Works
1	Pump	Centrifugal	2-in. discharge	Sump pump	Driven by 5-hp. Westinghouse motor, 1120 r.p.m.	Camden Iron Works
1	Crane	Traveling, hand operated	11 tons	Serves main pump room		Northern Engineering Co.
2	Boilers	Vertical water-tube	300 hp	Generate steam	150 lb. press., sat. steam, stokers	Babcock & Wilcox Co.
2	Stokers	Top feed	Projected area 18 sq.ft.	Serving boilers		Detroit Stoker Co.
1	Pump	Duplex	8x5x10-in.	Boiler feed pump		Canton-Hughes Pump Co.
1	Injector	....	2½-in.	Boiler feed		Penberthy Injector Co.
1	Heater	Open	600 hp.	Heat feed water	Use exhaust steam from pumps	Warren Webster & Co.

A barometric condenser maintains a vacuum of 25 in. on the engines. Cooling water is obtained from the river and is forced to the condenser head by a centrifugal pump driven by a double 8x10-in. vertical engine at a speed of 350 r.p.m.

The 24-in. pump is directly connected to a 150-hp., 550-volt, three-phase motor, having a speed of 360 r.p.m. Current at 6500 volts, supplied from the public lighting plant, is stepped down to the proper voltages for the motors and lamps in the station. The ordinary dry-weather flow is handled by this unit, which, due to the

Fig. 4. Angle-Compound Pumping Engines

large capacity of the water chamber, may be shut down during peak loads at the source of electric supply. The plant is operated on three shifts per day and ordinarily an hour and a half of pumping on each shift will dispose of the sewage. It is necessary, however, to keep the boilers banked and the steam units ready for service, as a heavy storm would soon supply enough surface water to tax the capacity of the station.

In the steam-generating part of the plant, two 300-hp. water-tube boilers are installed, with space for a third unit. Top-feed stokers with a projected grate area of 18 sq.ft. serve the boilers. City water is used as boiler feed, as the river water supplied to the condenser is muddy and unsuited for the purpose. Either a duplex pump or an injector handles the supply, which is raised to a temperature of 200 deg. in an open heater, taking exhaust steam from the feed and condenser pumps.

Meadowbrook run-of-mine coal is burned. It is stored in a 200-ton bunker in front of the boilers and delivered by hand to the stokers. Over the top of the bunker a ¼-ton electric hoist is suspended from an 8-in. I-beam. The track extends out of the south end of the building where coal is delivered by wagon. Eventually a dock will be built and coal will be delivered by water.

Due to the intermittent operation, satisfactory operating data are not available. In the guarantee the pumps were to have an efficiency of 70 per cent. and the engines to develop an indicated horsepower-hour on 14 lb. of saturated steam. The three units have a total capacity of 150,000,000 gal. in 24 hr. The building cost $144,000, the site $20,000 and the equipment $118,000. Per million gallons of daily capacity, the total equipment of the station cost $786.66. Smith, Hinchman & Grylls, of Detroit, were the architects and engineers for the station and Charles Meny is chief engineer of the plant.

The Rate of Radiation from bare steam pipes is approximately 3 B.t.u. per hr. for each square foot of surface exposed to a temperature difference of one degree between the steam inside the pipe and the air surrounding it. Therefore, the square feet of surface multiplied by the temperature difference (inside and outside of the pipe) multiplied by the constant 3 gives the total loss in B.t.u. per hour from a given pipe.

Interesting Accounts are to hand from Sweden regarding the results of trials lately conducted by a leading Swedish company on two sister steamers, one, the "Mjölner," being fitted with turbo-electrical engines and the other, the "Mimer," with ordinary triple-expansion engines. Each is of 2225 tons displacement and designed for a speed of 11 knots, a stipulation being that in each case the engines were to develop 900 i. hp. The most important factor, however, was with regard to the consumption of coal, which was guaranteed to be 30 per cent. less in the turbo-electrical vessel than in that fitted with the triple-expansion engines. For the trial trip, which lasted seven hours, the screws of the "Mimer" were fitted to the "Mjölner," so as to avoid possible difference arising from any difference in construction. During the trip the turbo-electrical engine developed 975 i. hp., or 75 more than the guaranteed maximum, while the average speed was 11.8 knots, as against 11 guaranteed. Good as these results are, the small consumption of coal exceeded the most sanguine expectations, amounting to 0.4 kg. per indicated horsepower, which works out at 35 per cent. less than the consumption on the sister ship, the "Mimer." Both steamers are to be employed in the coast trade and their hulls have been especially constructed for navigation on the ice.—"The Engineer."

Interesting Steam-Pipe Installation

By Hubert E. Collins

SYNOPSIS—Two old boiler plants are piped to give a common steam supply and to equalize the load on each. Details of the pipe-line construction are given.

The United Piece Dye Works, Lodi, N. J., were confronted with the problem of maintaining operation with an insufficient boiler capacity in one of the mills during the past winter and space did not permit of putting in more boilers. A larger plant, however, had some capacity to spare which would be of assistance to the other if properly connected. The two boiler plants were not far from 1500 ft. apart, and it was decided to connect the headers of the two boiler rooms with two 6-in. steam lines. The combined capacity of these two boiler rooms is around 3000 hp. Mill A has about 2000 boiler-horsepower capacity.

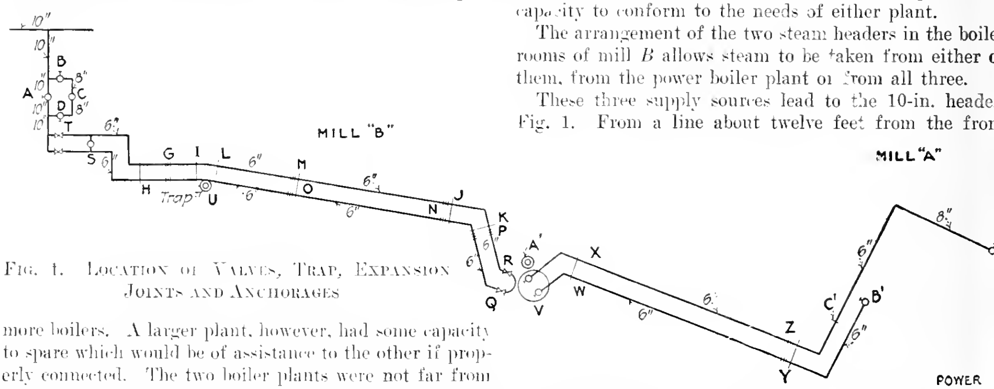


Fig. 1. Location of Valves, Trap, Expansion Joints and Anchorages

The boilers in mill B are connected to two headers, one over the front and the other over the rear of the settings. The power plant in mill B is connected to a single header, which is connected to the mill boiler headers with a 6-in. bleeder. These three headers are the sources of steam supply, connected as shown in Fig. 1.

The 6-in. header from the power plant runs into the one over the front of the boilers in the mill plant and the two headers there are connected with a 10-in. header. As this combined boiler plant carries 120 lb. pressure and the boilers at mill A 75 lb., a reducing valve is situated at the mill B end of the pipe line.

Equalizing Steam Lines

The lines connecting these two boiler plants are called equalizing steam lines, as the purpose is to equalize the capacity to conform to the needs of either plant.

The arrangement of the two steam headers in the boiler rooms of mill B allows steam to be taken from either of them, from the power boiler plant or from all three.

These three supply sources lead to the 10-in. header, Fig. 1. From a line about twelve feet from the front header, the 10-in. line branches to the outside wall of the building next to the river. This line has a 10-in. stop valve A, which is bypassed through an 8-in. reducing and regulating valve C, with stop valves B and D on each side of it. At the point where the 10-in. line comes outside the wall over the smoke breeching, two 6-in. lines are taken through two 6-in. valves. These two lines run parallel to the mill A boiler plant. From the 10-in. header they run at right angles horizontally to the wall of the power boiler plant, turn at a right angle and pass over the smoke flue on to the corner, then another right-

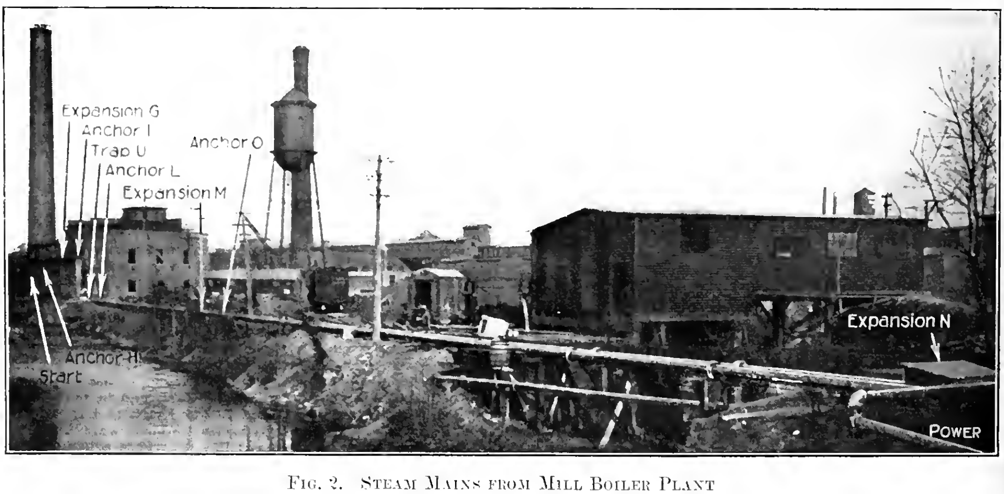


Fig. 2. Steam Mains from Mill Boiler Plant

angle turn and along to a point midway of the engine-room wall, where they drop to the level of the river bank. The lines are supported on brackets made fast to the wall of the building, and are pitched in the direction of flow with a fall of 1 in. in 15 ft.

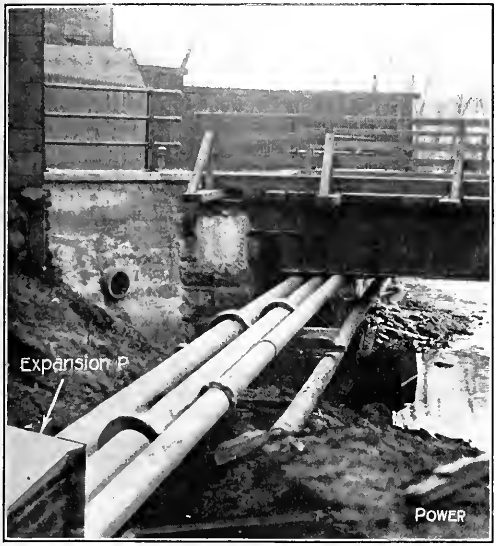


FIG. 3. TWO STEAM LINES RUNNING UNDER A BRIDGE

The pipes are anchored at the first corner of the power boiler-plant building and near the pier support outside the engine room, where they take the first drop. Midway between these anchorages *H* and *I* is placed the first slip expansion joint *G*.

After the first drop the lines run horizontally along the river bank on wood supports. At the bottom of the first fall is placed a tee on each line that acts as a drop-leg, from which the drippage is removed. The lines are pitched down along the river bank in the direction of flow, 8 in. to 15 ft., to a point beyond the railroad trestle (Fig. 2), also at the turn between the anchors *J* and *K* (Fig. 1). At the first support from the power boiler plant and the engine house is the anchor *L*. The distance from these third anchors to the fourth set on the river bank is 256 ft. A set of expansion joints *M* is placed in front of the fourth anchorage. From fourth to the fifth anchorage is 237 ft. and the expansions *N* are placed just in front of the anchorage *J*.

Fig. 2 gives a view of the steam lines as they come from mill *B* boiler plant around and along the wall of the power boiler plant to the point where they drop to the ground surface and along the river bank to the expansion *N*, at which point they turn to run under the bridge to reach the yard of mill *A*. At the extreme left of Fig. 2 can be seen the smoke flue, over which these steam lines pass. The pipes are supported on the walls above the ground by brackets. At the extreme right is the housing for the expansion joints *N*.

Ten feet beyond this the lines drop 21 in., then turn to go under a bridge. At the first support after turning from the railroad track is the anchorage *J*. Just beyond is the expansion set *P*. The lines run under the bridge with a fall of about 1 in. in 15 ft. and next to the retaining wall of the mill *A* side the drop is 21 in. At this point the lines turn at another angle and pass through this wall underground to the receiver room, where just inside the wall in the pipe tunnel are placed the valves *Q* and *R* on the horizontal runs. From these, the lines are joined in a Y and empty into a receiver, which catches all drippage from the valves *S* and *T*. It also takes care of the drippage from the vertical lines over the receiver, and which is dropped by the trap *U*, placed in the receiver pit. From the receiver the lines are taken from a Y on the top. Two 6-in. valves *V* and *W* are placed on the top of this Y and from these valves the lines extend through the roof of the receiver house and are carried over the roof of the adjacent buildings.

Fig. 3 shows the two steam lines near the point where they turn toward the bridge, looking toward the trolley bridge and mill *A* yard from the mill *B*. The first pipe is for water; the two steam lines are just back of it.

Fig. 4 shows the steam pipes passing from under the bridge through the concrete abutment in front of the receiver house. The steam lines in this view are the ones on a line with the lower side of the bridge girders. The steam pipes are also shown as they leave the receiver house to the level of the roof of the adjacent building and rest on the roof supports.

At the second roof support is placed the anchor *X* (Fig. 1). The pipes have a fall of 1 in. in 15 ft. over the roofs of the buildings and are pitched down from the point over the receiver house. Fig. 5 shows the lines on the roofs from the point over the receiver house almost to

FIG. 4. VIEW FROM THE OTHER SIDE OF THE BRIDGE

the first turn, shown in Fig. 6 at the extreme left. On the second support beyond this turn (not shown) is placed anchor *Y*, Fig. 1, and in front of it is the expansion *Z*.

On the edge of the roof at the alleyway the lines break at right angles horizontally and run over the alleyway roof. One line feeds the finishing-room side of mill *A*, going through the roof of the alleyway to the finishing-room steam main, which runs horizontally and at right angles to the equalizing lines just under the roof. Just in front of this break in the line is a drop-leg, to which is attached a trap, and next to this drop-leg is the valve

B'. The 6-in. drop-leg ends in a blank flange, from which the drip line is taken to the trap in the basement almost underneath the drop-leg. The other equalizing line supplies the dye house and runs across the roadway in front of the alley, turns at right angles horizontally for a few inches and then drops to the 8-in. dye-house main. At the second support over the alley is placed the anchor *C''* on the dye-house main only. Expansion in the finishing-room main is taken care of by the drop

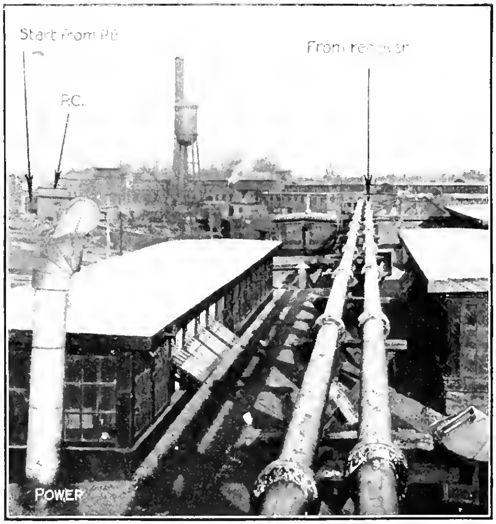


FIG. 5. PIPE LINES ON ROOF

of Fig. 1 and the other illustrations will show as few turns and bends as circumstances would allow. The exposure to the weather required care as to the drainage and the amount of pitch given seems to have been adequate.

The supports were required to carry an average of 530 lb. each when spaced 15 ft. apart. Figs. 7 and 8 show the type of the ground and roof supports, respectively.

The ground supports have a plank 10 in. by 5 ft. on the bottom to take the weight. They are bedded on stone or brick. The two side braces are buried in the earth and thus take up any lateral thrust in the direction of the pipe lines.

The roof supports are braced to take this thrust. In order to distribute the weight on the roof as much as possible, a continuous line of plank was placed under the legs of the supports.

Fig. 9 represents the type of support used on the side walls of the buildings that the lines skirted. A channel was placed at the back of the wall to distribute the load.

Fig. 10 shows how the anchorage of the pipe is made at the different points. It consists of a distance piece made of ⅝x3-in. iron, to hold the pipe in line above the wood support, and a strap of the same size of iron to hold the pipe down.

Fig. 11 shows the method of anchoring along the river bank. In addition to the clamp on the support, there is a clamp on the pipe with a rod leading from it to a plank buried some feet in front of the support.

The pipes were covered with 85 per cent. magnesia molded nonconducting material, wired on and covered with magnesia cement on the flanges and fittings. Over the covering was placed rubberoid paper wired on and over this was sewed tarred canvas.

Settling of the supports on the river bank was looked

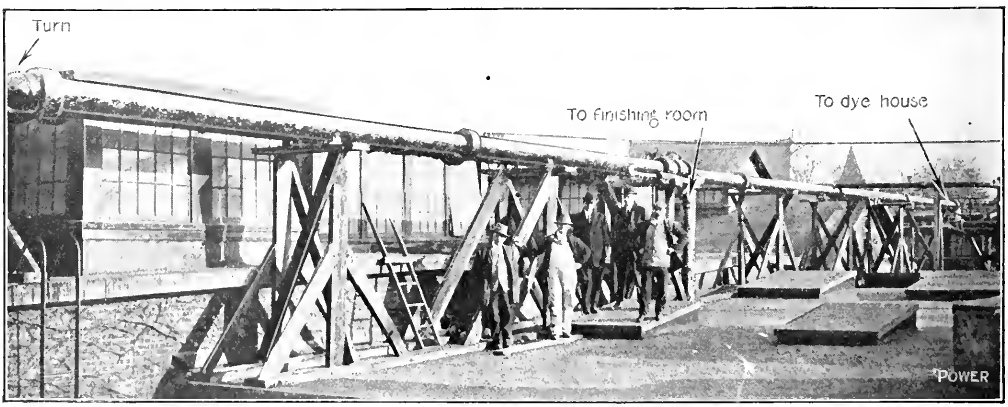


FIG. 6. NEAR VIEW OF PIPE LINES ON ROOF AND METHOD OF SUPPORTING THEM

through the roof of the alleyway. The expansion in the dye-house main beyond the anchor *C''* is taken care of at the drop to the 8-in. main, which forms a swing joint.

DETAILS OF CONSTRUCTION

The details of construction of the line and its accessories are of interest, because some of the conditions met were outside the average experience.

The installation of these lines offered many difficulties, as much of them were exposed to the weather. A study

for and taken care of by placing the loose lengths of pipe on the supports for about ten days before the roller bases were lined up. There was considerable rain during that time and therefore there was but little settling after the line was in position.

SOME PERFORMANCES

When the steam lines were put under steam pressure, there were less than ten leaks on all this piping and only three defective flanges.

While the pipes were still bare and the temperature of the atmosphere was 30 deg. F., the lines were heated and put in commission within 25 min. without water-hammer from condensation.

After the lines were covered and in commission, the losses by condensation were checked. The two dumping traps on the line were observed to take, on an average, 8 sec. for an operation. As the amount of water discharged by each operation was known, a close estimate of the amount of condensation was secured. The trap at the receiver discharges at each operation 65 lb. of water and number A' 20 lb. During a given period in December the traps were watched and it was observed that the trap U was operated five times per hour during the 24, and trap A' three times. The amount of steam flowing through the pipes was recorded by steam-flow meters.

The average amount of steam per hour for the six days of the observation was 18,990 lb.

Amount of condensation equaled:

$$65 \times 5 \times 24 = 7800$$

$$20 \times 3 \times 24 = 1440 \text{ for finishing-room side.}$$

$$1440 \text{ for dye-house side.}$$

$$\text{Total for 24 hr., } 10,680 \text{ lb.}$$

$$\frac{10,680}{24} = 445 \textit{ lb. per hr.}$$

$$\frac{445}{18,990} = 2.3 \textit{ per cent. loss by condensation}$$

The chart (Fig. 12) gives some idea of the performance of the two lines. The heavy line gives the steam pressure at the source of supply at the pressure-regulating valve in mill B. The dotted lines give the pressures on each of the two lines at a distance close to 1300 ft. from the source of supply. One point gained by these equalizing lines was that there was a more uniform pressure in mill A, as shown by this chart, whereas prior to this the daily steam variation amounted to as high as 45 lb. pressure. The drop in pressure in the 1300 ft. of pipe can also be observed. At the point of maximum drop, the amount is 15 lb., while the two 6-in. pipes are supplying steam at the rate of 30,000 lb. per hr.

When the lines were first installed a trap was placed on the drop-legs at the first drop outside the wall of the engine room. It was later observed that after the lines were warmed up there was not enough condensation collected at that point to operate the trap more than once or twice per day. The trap at this point was therefore disconnected and only the drip valve left to use when first warming up.

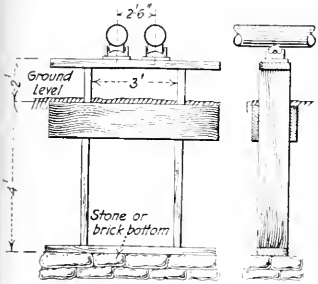


FIG. 7. WOODEN GROUND SUPPORT

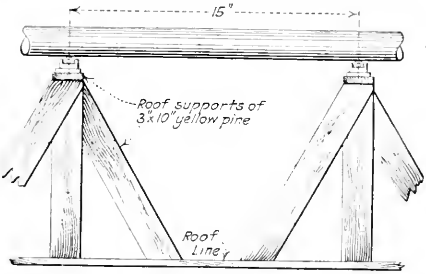


FIG. 8. PIPE SUPPORT ON ROOF

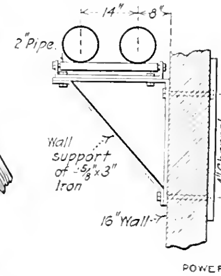


FIG. 9. WALL SUPPORT

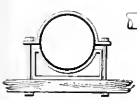


FIG. 10. ANCHORAGE

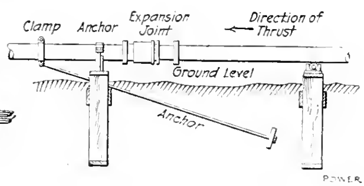


FIG. 11. METHOD OF ANCHORAGE

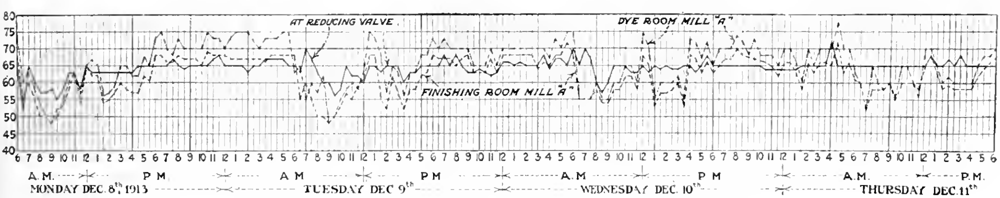


FIG. 12. CHARTS OF STEAM PRESSURE ON STEAM LINES

The Effect of Vanadium in plain carbon-steel castings is to increase the elastic limit about 30 per cent., giving a much higher proportion of available strength for the same ultimate strength.

An Effective Treatment by which the porosity of cement used in constructional work can be stopped and the free lime neutralized is said to be the painting of the surface with a solution of 8¾ lb. of zinc sulphate in a gallon of water. A reaction between the zinc sulphate and the free lime occurs as deeply as the solution penetrates, and by it the insoluble neutral salts, calcium sulphate and zinc hydroxide are precipitated into the pores. This priming coat should be given some 96 hr. to dry, the surface then being brushed and painted with two coats of a good cement paint.

Keeping Track of Plant Operation

By A. D. Williams

SYNOPSIS—Recording instruments and system of plant records employed at the Cleveland Municipal plant.

Economic conditions make it necessary to keep an accurate check upon each process of power-plant operation. The new municipal plant in Cleveland is provided with facilities for determining the heat value of coal and the analysis of coal, ashes and flue gases; instruments and meters are installed which either indicate or record changes in the operating conditions; and a few simple forms provide a complete report of operation.

The bunkers at the plant have a storage capacity of 3400 tons, and the coal cars are spotted on two tracks above it, the coal being dumped through steel-bar gratings which are shown in Fig. 1. Telpher weighing larries having a capacity of two tons each are used to transport the coal from the bunker spouts to the stoker hoppers. Each telpher operator turns in a report giving the weight of coal delivered to each boiler and the time of delivery. These weights are totalized for each watch and entered on the daily plant report.

This daily plant report is arranged to give a complete insight into station operation, there being twenty items to be filled in for each watch. Sixteen of these are obtained from the readings of meters or recording instruments, three are computed from other items and one is obtained by reference to a steam table. The equipment of meters and gages in this plant is interesting. Fig. 2 shows the engineer's office where eight different recording instruments are installed. The readings of the CO_2 recorder are checked every few days by an Orsat apparatus. One electric meter is found in the engineer's office; this is a graphic megowatt meter which totalizes the entire electrical output of the three main generating units.

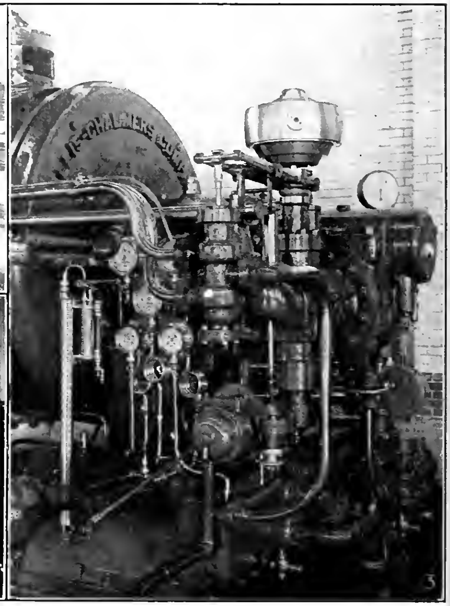
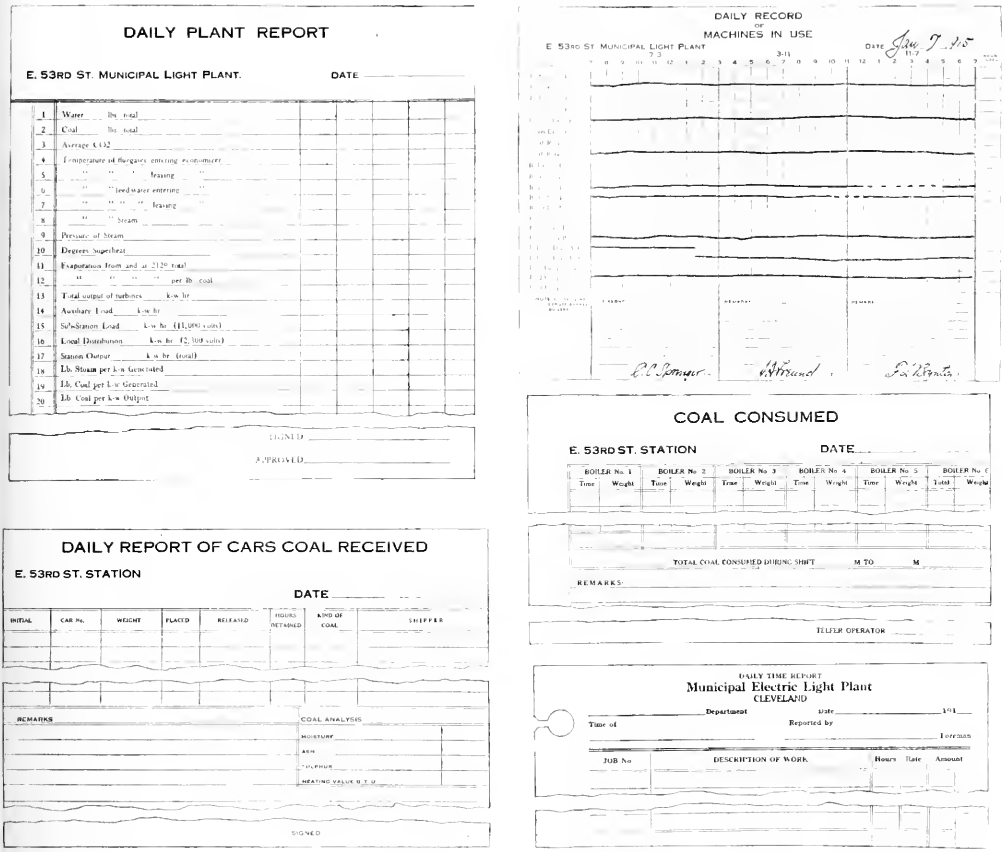


Fig. 1. Grating over Coal Bunker. Fig. 2. Office. Fig. 3. Turbine Governor and Gages

Slack coal is delivered at the plant in dump cars run on a switch over the coal bunker, and four samples for analysis are taken from each car. All the samples for each shipment are mixed and crushed, and two laboratory samples are taken—one for analysis in the laboratory, the other to be held as a check sample in case any question arises. The chemist determines the moisture, ash and sulphur content of the coal and its heat value, the last determination being made by a Parr oxygen bomb calorimeter. The price paid for the coal is based upon a specified standard of 13,000 to 13,099 B.t.u. with less than 15 per cent. ash and less than 3 per cent. sulphur. Lower heat value and higher ash and sulphur are penalized, while a premium is paid for a higher heat value. A blank form is provided upon which all shipments of coal received are reported by the chemist, together with its analysis.

The feed water for the boilers is metered or weighed by a V-notch meter having a capacity of 275,000 lb. per hour, and its temperature is recorded before it enters and after it leaves the economizers. The temperature of the flue gases is also recorded at both ends of the economizers, and the temperature of the ingoing gases is a continual check upon the combustion results obtained



FORMS FOR OPERATING RECORDS

in the boiler furnace. A further check upon boiler operation is obtained from the indicating flow meter showing the steam output and by draft gages which show the draft pressure in the combustion chamber and in the boiler blast main, while the steam temperature and pressure in the header actuate recorders installed in the engineer's office. An indicating draft gage in the induced-draft fan room shows the draft at this point in the flue.

The test of the boilers and stokers developed an interesting draft feature. In these boilers, a cross-section of which was shown in POWER of Jan. 19, the combustion chamber is extremely high, resembling the well known Delray setting. The following draft readings were obtained:

Test No	1	2	3	4	5
Per cent. of rated load	156.87	106.53	149.51	197.86	273.83
Draft, inches of water					
Furnace	—0.09	—0.06	—0.05	—0.09	—0.08
Top of first pass	+0.19	+0.16	+0.22	+0.16	+0.15
Bottom of last pass	+0.02	+0.06	+0.04	—0.07	—0.15
Upper damper	—0.10	+0.07	—0.03	—0.43	—0.05

PRINCIPAL EQUIPMENT OF METERS AND GAGES, EAST 53D ST. STATION, CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT

No.	Equipment	Kind	Use	Location	Maker
1	Barometer..	Mercurial. .	Atmospheric pressure..	Turbine room	
1	Pressure gage..	Indicating	Exhaust pressure	Main unit	
1	Pressure gage	Indicating	Inlet pressure	Main unit ...	
1	Pressure gage	Indicating	Steam pressure	Main unit ...	
1	Pressure gage.	Indicating	Bearing-oil pressure	Main unit ...	
1	Pressure gage.	Indicating	Relay-oil pressure	Main unit ...	
1	Vacuum gage	Mercurial..	Condenser vacuum	Main unit .	
1	Tachometer..	..	Speed indicator	Main unit	Schuchardt & Schutte
1	Flow meter.	G. E. Indicating	Steam from boilers	On boiler setting	General Electric Co
1	Draft gage..	Indicating	Boiler blast main	On boiler setting	Precision Instrument Co.
1	Draft gage..	Inclined tube	Boiler firebox	Each boiler setting	Schaeffer & Budenberg
1	Draft gage .	Indicating	Draft-economizer outlet	Induced draft fan room	Precision Instrument Co.
1	Thermometer	Recording	Gases from economizer	South end of boiler room .	The Bristol Co
1	Steam gage..	Recording	Header steam pressure	Engineer's office	Schaeffer & Budenberg
1	Thermometer.	Recording	Steam in header	Engineer's office	The Bristol Co.
1	Thermometer	Recording	Feed water to economizer	Engineer's office	The Bristol Co.
1	Thermometer..	Recording	Feed water from economizer	Engineer's office	The Bristol Co.
1	Thermometer..	Recording	Gases to economizer . .	Engineer's office	The Bristol Co
1	CO_2 recorder..	Simmance-Abady	Combustion record .	Engineer's office	Precision Instrument Co.
1	Feed-water meter..	Lea V-notch.. Integrating and recording.	Feed-water supply .	Recorder in engineer's office	Yarnell-Waring Co
1	Totalizing meter (electric)........ .	Graphic recording, 3 circuits ..	Station load in megowatts..	Engineer's Office .. .	Westinghouse E. & M. Co.

Each auxiliary turbine for power and exciter service has a gage and tachometer similar to those for the main units
The switchboard equipment comprises the usual integrating and indicating meters

These readings show positive pressure at the top of the first pass, which is rather remarkable. At the same time the CO_2 in all the tests was over 15 per cent, and in only two did the oxygen run over 3 per cent.

Priming a Centrifugal Pump

By J. F. Jones

Centrifugal pumps, unless submerged, must be primed before they will operate. The experience of the writer with priming while in charge of an irrigation plant in the Gulf Coast regions of Texas may be interesting.

This plant lifts water from the San Jacinto River to a 300-ft. wooden flume, which discharges into a canal system watering several thousand acres of rice. The four centrifugal pumps used have rather long discharge pipes, Fig. 1. The pump shown is a 30-in. single-suction, 25,000-gal. per min. capacity pump and is rope-driven by a Greenwald compound condensing engine.

The discharge pipe is 67 ft. long, the upper end being closed by a flap-valve. For priming, a steam ejector was connected to a 2-in. hole on top of the pump casing. The ejector produced enough vacuum in the suction-pipe, pump and discharge pipe to fill the suction pipe and pump with water; then the engine would be started and brought up to speed.

This is the usual method of starting recommended by the pump builders. The length of the suction and discharge pipes caused many small air leaks, which condition was further aggravated by the difficulty of making the flap-valve seat air-tight. One night when shutting

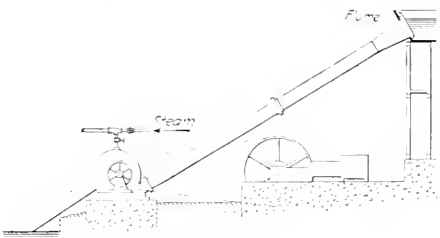


Fig. 1. Relative Locations of Pump, Engine and Flume

down there was a loud report and a stream of water came pouring down from the end of the flume. It was found that the upper end of the discharge pipe had collapsed for a distance of several feet and that the heavy cast-iron flange on its end was broken and torn loose from the flume.

The cause of the accident was plain. When the flap-valve on the end of the discharge pipe closed, the water ran down through the pump, forming a vacuum in the pipe, and the atmospheric pressure collapsed it. Just why a pipe calculated to resist an internal pressure of 150 lb. should fail under an external pressure of less than 15 lb. may not be apparent at a glance, but there was no disputing the fact. It was clearly time to make a change in the method of starting this pump.

First, the flap-valve was removed and a swinging gate was put in the flume several feet from the end of the discharge pipe which, being open to the air, could not be subject to a vacuum. Second, the ejector was taken off the top of the pump casing and connected to a 1¼-in. pipe-threaded hole drilled in the highest part of the suction elbow, Fig. 2. With this arrangement, the pump is started as follows:

First, it is necessary to have the lower end of the

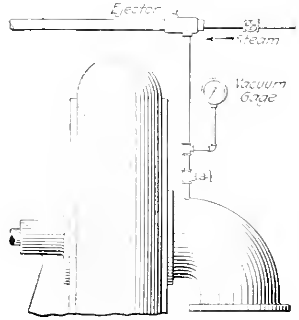


Fig. 2. How the Present Priming Ejector Is Connected

discharge pipe contain enough water to seal the discharge outlet of the pump casing. The leakage from the gate in the flume was usually ample for this purpose. Except when the water in the flume was low, it would be necessary to open the gate by hand to allow enough water to flow back into the discharge pipe.

Second, the throttle would be opened and the engine brought up to speed, as shown by the cutoff hooks beginning to trip by the action of the governor. When the ejector was started, and as the sealing water would be held in place by the revolving impeller, a vacuum was created in the suction pipe and in the pump sufficient to cause them to fill with water. When the pump "got the load," as shown by a slight decrease of speed, the throttle was opened.

As the ejector no longer had to exhaust the air from the 67 ft. of discharge pipe, the time required to start the pump was shortened, usually taking only four or five minutes for priming. A vacuum gage on the suction side of the ejector was found desirable.

Simplified Formulas—Two rules or formulas for finding the capacity of tanks in U. S. gallons and for finding the heating surfaces of boiler tubes are given below, which are easily worked out by simple multiplication, no division being necessary:

Rule—To find the capacity of a cylindrical tank in U. S. gallons, square the diameter in inches, multiply by the length or height in inches and multiply the product by the constant 0.0034.

Formula, $D^2 \times H \times 0.0034 = \text{capacity}$

Proof, $0.7854 \div 231 = 0.0034$ the constant

Rule—To find the heating surface of boiler tubes, multiply the diameter of the tubes in inches by their length in feet and that product by the constant 0.2618.

Formula, $D \times L \times 0.2618 = \text{heating surface}$

Proof, 3.1416 cir $\div$ 12 in. $=$ 0.2618

The Eighth Annual Report of the District Police of the State of Massachusetts, for the year ending Oct. 31, 1914, regarding the examination and licensing of stationary engineers, contains the following: The number of applicants examined for licenses as engineers or firemen was 6490, of which 2955 were granted licenses and 3535 were rejected; for operators of hoisting machinery 147 were examined, 125 passed and 22 were rejected; grand total of applications, 6637; number licenses, 3080; rejected, 3557

Just for Fun

[More "original ideas" sent in by readers in response to our request in the Jan. 19 issue for stories of amusing stupidity.—EDITOR.]

In a certain power plant which the writer visits occasionally, there is a recording boiler feed-water meter. Some six months ago the nozzle became so stopped up with the sediment in the feed water that the records were worthless. Nevertheless, the engineer religiously changes the charts every day and reads the integrating dial, in spite of the fact that he knows the nozzle is plugged up.—*Loren L. Hebberd, Milwaukee, Wis.*

The following piece of rank stupidity is reported "just for fun." We purchased a forced-draft system for a boiler, which was a miserable failure. When the writer told the representative of the company the facts of the case he hauled out his data sheet and started to take down the data which were given him. He finally asked what kind of coal we burned, and when told it was pea coal he immediately said: "That's the reason it would not work. This blower is so delicately adjusted and carefully designed for buckwheat coal that it could not be expected to work on pea coal."—*T. Newbury, Monroe, N. Y.*

A 10-kw. dynamo was used to light the mill, and short-circuits were common. One night a short came on that nearly threw the belt. I looked the main mill over, but failed to find it. In a short time it came on again, and I finally asked some of the men if they had done anything to the wiring. One of them said he had put an extension on a certain light, but had insulated it so that he knew it was all right.

He had found a couple of pieces of bare No. 12 wire, also a long piece of rubber tube. He twisted the wires together, put them in the rubber tube, attached the socket to one end, and hooked the other ends on the circuit wires. He said he didn't see how there could be trouble, when they were covered with the rubber tube.—*V. C. Wood, Copenhagen, N. Y.*

"Last week," said a friend of mine, "I was called to inspect an engine installation that our firm had sold. Complaint had been made that neither the pump nor the injector that came with the outfit would work. We had sold engines and boilers equipped with pumps and injectors of this particular kind for many years and never received any complaints about them. I was rather curious and somewhat perplexed as to what the trouble could be.

"When I arrived at the plant and the steam pressure was brought up to normal, I attached one end of a hose to the suction side of the feed pump and put the other into a pail of water. The first stroke of the pump emptied the pail. Then, with a barrel of water I tested out the pump and injector and both worked perfectly. There was only one conclusion to arrive at, and to the accompaniment of a few choice remarks the cover over the well used as a source of water-supply was removed and revealed the trouble—the well was dry.

"The manager was told that the cost of the lesson that neither pump nor injector could create water would be an even $50."—*C. E. Anderson, Chicago, Ill.*

Mixed-Pressure Turbine and Condenser Outfit

The Columbia Plate Glass Co., Blairsville, Penn., has recognized that the utilization of exhaust steam for the generation of power would effect a desirable saving in coal costs and help the production by giving better fa-

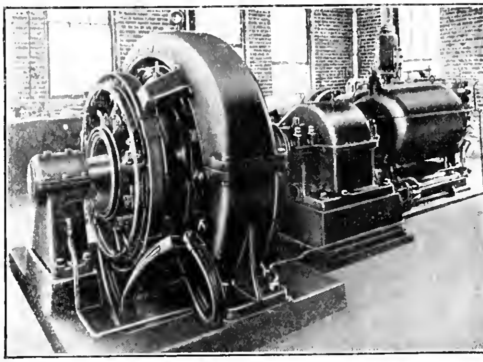


FIG. 1. THE MIXED-PRESSURE TURBINE UNIT

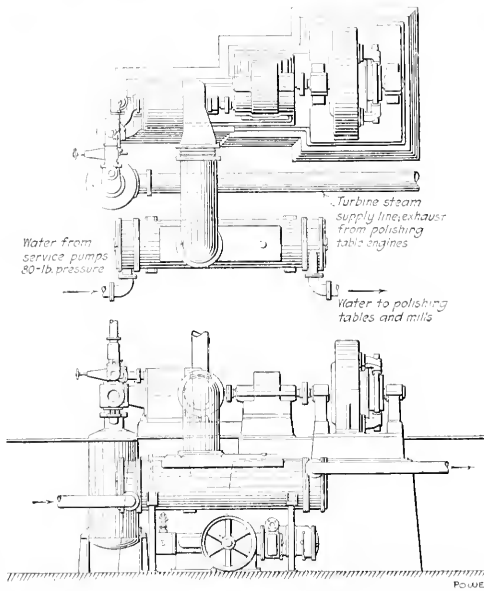


FIG. 2. ARRANGEMENT OF THE TURBINE AND CONDENSER

cilities for output. Accordingly, a 300-kw. mixed-pressure Kerr steam turbine was purchased, Fig. 1. It is a 450-hp. capacity, seven-stage, impulse-type unit connected through reduction gears to a 600-r.p.m., direct-current generator. The exhaust steam from several Corliss engines is piped to the turbine and ordinarily enough steam is obtained from this source, at a pressure of about one pound above atmosphere, to generate all of the electricity required in the plant. Whenever the Corliss engines are shut down, live steam is admitted automatically through expanding nozzles.

The turbine exhausts into a surface condenser of the water-works type—that is, it is installed in the water-supply line to the mills, Fig. 2, and this water produces the cooling effect necessary for a vacuum of 28 in. on its way to the grinding tables. This feature of the installation eliminates any pumping of water for the condenser and makes use of the water which is being pumped. The condenser is designed for a water pressure of 80 lb., the pressure carried in the mill lines.

The turbine is placed beside two engine-driven generator sets which have operated continuously on high-pressure steam for years. It is estimated that these machines used about $20 worth of coal per day, so that the saving effected by the exhaust turbine is about $6000 per year, or enough to cover the cost of the machine in a period of two years. The turbine operates continuously twenty-four hours a day, six days a week.

Oil under 6 lb. pressure is pumped to the bearing, and then flows by gravity to an oil reservoir in the bedplate; there it is strained and cooled. A small steam turbine-driven centrifugal pump is bolted on this bedplate and used for starting the oiling system before the turbine is started.

Strength of Diagonal Joints

By J. E. Terman

Nearly all authorities on boiler construction have advocated the use of diagonal seams for boiler patches of small size. Hence, the common use of the horseshoe and diamond shapes, where bags or similar defects in the vicinity of girth seams have made the removal of a part of the shell plate necessary. The writer has long been an advocate of such a method of repair and does not now wish to be understood as having changed.

However, analyzing diagonal boiler joints in the light of what is known of the strength of riveted joints, it appears possible that there may be an error in assuming that such angular joints, unless occupying a position of angularity of 45 deg. or more with a line parallel to the axis of the boiler, are superior in strength to joints of the same design placed on lines parallel to the axis of the boiler.

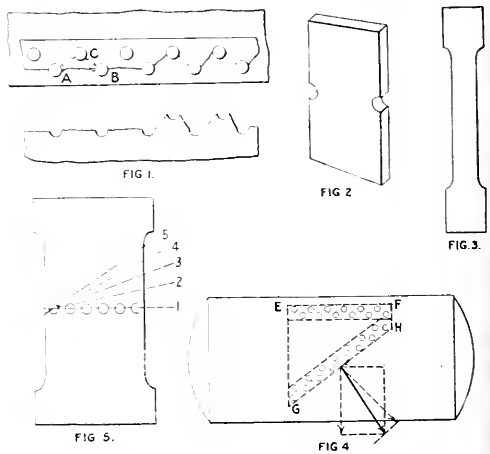
It was determined by experiments on riveted joints made many years ago, that in order to insure the breaking of the net section of a double-riveted joint as illustrated in Fig. 1, the combined net section of the metal from *A* to *C* and *C* to *B* would have to be about 30 to 35 per cent. greater than from *A* to *B*. With less metal on the diagonals than indicated, the break would be liable to occur, as illustrated on the right-hand side of Fig. 1, at the last space between rivets.

There are probably two reasons for the diminution of strength in the angular section, the first being that the material is not subjected to true tensile stress, but is partly in shear and is weaker to resist a stress of this character; the second reason is, the material can draw down more readily in the inclined sections than in the longitudinal. The latter reason is based on the effect noted in testing materials, where, if a sample of plate is tested in the shape which was formerly used by the U. S. Government and illustrated in Fig. 2, the tested tensile strength would be about 10,000 lb. higher than if tested in the form shown in Fig. 3, which is the standard, because the area of metal at the time of failure is greater than would be the case with the same-sized test specimen arranged in the form illustrated in Fig. 3.

This increase of area is due to the reinforcing effect of the additional metal (Fig. 2) close to the ruptured section, the radii of the semicircles on the side of the test specimen being only one-half inch.

Rivet holes in a plate produce the same effect on the apparent strength of the net section of metal between the holes as is produced by the semicircles in Fig. 2, and this effect is maximum when the line of holes is at right angles to the direction of applied stress and diminishes as the angle between the line of holes and the direction of applied stress decreases.

It is, of course, true, as can be demonstrated by calculation, that the stresses in a cylinder due to internal pressure and at right angles to the direction of an angular joint such as *GH*, Fig. 4, is less per unit length of joint than if the joint occupied a position parallel with the axis of the cylinder, as *EF*. However, the girth-wise stress is the same in all parts of a cylinder, and unless the angle between *EF* and *GH* is such that the net sec-



Proposed Tests for Diagonal Seams

tion of metal from *G* to *H* is 30 per cent. or more in excess of the net section of metal from *E* to *F*, then failure along *GH* may be expected, if the test results for the strength of angular net sections in riveted joints hold good in such a case.

It appears that no tests have been made to determine the effect on its strength of varying the angle of a joint with respect to the direction of the applied stress. However, it may be inferred from the behavior of the angular sections between rivet holes in tests made on riveted joints located at right angles to the applied stress, that if a series of test specimens were prepared as illustrated in Fig. 5, the rivet holes being drilled the same distance apart for each specimen, but the line of holes occupying a different angle on each specimen, as No. 1, No. 2, No. 3, etc., indicated in Fig. 5, the breaking strength of the different specimens would probably not vary greatly. If such tests were conducted using a sufficiently wide range of angles, they would demonstrate in a measure if the angularity of a joint as commonly used in making repairs is a real factor in determining its strength. It might be argued that in such a test the actual conditions with respect to the stresses applied to a joint on a cylinder subjected to internal pressure would not be reproduced, because in the latter case there would be longitudinal stresses produced by the pressure acting on the heads of the cylinder. However, by including such longitudinal stresses the joint could hardly be expected to show greater strength than when considered without taking them into account. Also, in the horizontal-tubular type of boiler, it is possible that the longitudinal stresses in the shell along the bottom of the boiler are a negligible quantity. After all is said and done in the matter of estimating the strength of short boiler seams as used for patches, we cannot hope to have come very close to the true facts in the case, because the distribution of the stresses in the shell or patch, due to difference in the fitting of the patch and fit of rivets in the holes, would be likely to materially change the results in every case.

The intent of this article, as stated at the beginning, is not to discourage the use of diagonal boiler joints for patches, but to show that by the usual methods of calculating the strength of such joints there is a possibility that some of the most important factors entering the problem have been neglected. It is also probable that considerable changes in the angularity of such joints may produce relatively slight changes in their strength.

The determination of the facts, as regards the effect on the strength of a test specimen when pierced by rows of rivet holes equally spaced, but occupying various angles with respect to the line of direction of stress, as illustrated in Fig. 5, would be an experiment easily performed by anyone having the facilities to make tensile tests on large specimens, and the results would be of great interest to all engaged in boiler design and construction.

Firebrick for Boiler Furnaces

By A. D. Williams

Modern large combustion chambers with high boiler settings result in much higher furnace temperatures than are reached in those settings where the cold tubes are close to the coal bed. These high temperatures mean that the materials for furnace construction must have a higher refractory resistance to meet the demands of the service. The grades of firebrick which proved everything to be desired with the old-style setting may not be at all satisfactory with furnaces of large volume. The chemical composition of a brick and its fusion temperature are not reliable indications of its refractoriness in service, for structural differences have an effect upon wearing qualities.

Gilbert Rigg* gave the following properties to be possessed by a product which is to be used as a refractory:

1. Absolute infusibility at the highest working temperatures.

2. Complete absence of deformation and shrinking under working conditions.

3. Mechanical strength.

4. Complete resistance to the penetration of vapors, slags, etc.

5. A chemical composition fitted to withstand as completely as possible the corrosive action of the substances to which the bricks are exposed.

6. Equality and fixity of form and dimensions.

*See "Metallurgical and Chemical Engineer" for May, 1910.

The writer would add two more properties as being desirable, although some might, perhaps, consider them covered by the properties specified by Mr. Rigg. They are:

7. Resistance to erosion.

8. The ability to withstand sudden temperature changes without frittering or spalling off.

Technological paper No. 10 of the Bureau of Standards gives the melting points of various bricks as follows:

Kind of Brick	Melting Point, Degrees C	Melting Point, Degrees F	Chemical Nature
Fireclay	1555-1725	2863-3169	Neutral or acid
Bauxite	1565-1785	2881-3277	Basic or neutral
Silica	1700-1705	3092-3101	Acid
Chromite	2050	3754	Neutral
Magnesia	2165	3993	Basic

Iron, silica, alumina, lime and sulphur are the clinker-forming elements of coal. The degree of fusibility of the clinker varies directly as the percentages of sulphur, iron and lime and inversely as the percentages of silica and alumina.* The tendency of the iron to combine with silica in the coal and ash and form a slag is well known, and a cinder of this kind will have a strong affinity for the silica in the brickwork. This is one of the reasons that silica and fireclay brick have a strong tendency to disintegrate at high temperatures along the side of the furnace. Cinder in cooler furnaces sticks to the brickwork, which is often damaged in the attempts made to bar the clinker loose. With certain kinds of cinder it is possible to feed a small quantity of limestone and melt a pasty slag free from the side walls. Fluorspar has a similar effect upon some cinder. Both of these remedies should be used with discretion and care to avoid fluxing the cinder to such an extent that it will flow down on the grate bars and chill there, in which case it will be more troublesome than in its original consistency.

There is no reason why silica brick should not be used above the cinder line, for the upper parts of the walls and for coking arches, where they are exposed to the action of the flame only. Silica brick are used in this manner in basic openhearth furnaces and have proved durable.

Bauxite brick have been tried to some extent for the side walls of the firebox. These brick cost from two to three times as much as silica or high-grade fireclay brick. They are very hard and tough, the cinder does not stick to them and they last considerably longer than silica brick where exposed to the action of the slag. They have one serious disadvantage—a tendency to spall or fritter off if suddenly chilled. In a firebox this is often troublesome. The barring doors for the fires are generally located close to the side walls, and whenever these doors are opened a blast of cold air will be drawn in along the walls unless the draft can be so well balanced that the furnace is slightly above or at the same pressure as the atmosphere. When the furnace is below the atmospheric pressure this chilling draft results in rapid spalling close to the door and it may be necessary to shut the boiler down to patch this portion of the lining long before the rest of the fire requires repairs. Bauxite brick, even with this disadvantage, have proven quite durable, lasting from three to eight times as long as the cheaper brick. Although bauxite is extremely refractory, it must be almost completely calcined, otherwise it will shrink excessively at furnace temperatures. These brick must be burned in an oxidizing atmosphere, otherwise the iron compounds in the

*That sulphur causes clinkering is not generally agreed. The belief that it has no appreciable influence on clinkering is on the increase.—EDITOR.

bauxite will be reduced and the brick will have a low heat resistance. Bauxite brick are frequently considered as basic, though in many ways they partake of a neutral character. Bauxite is mined extensively as an ore of aluminum. The average composition of that from Georgia is:

Silica (SiO_2)	3.00 per cent.
Iron peroxide (Fe_2O_3)	1.50 per cent.
Alumina (Al_2O_3)	58.67 per cent.
Water (H_2O)	32.33 per cent.
Titanium (TiO_2)	4.50 per cent.

Another material used in making refractories which may possess some possibilities of assisting in building durable fireboxes is chrome iron ore or chromite. These brick cost more than twice as much as bauxite brick, but are neutral in character. This material is infusible and it is difficult to sinter it thoroughly, and unless thoroughly sintered it does not stand erosion.

TYPICAL ANALYSIS OF CHROMITE

Sesquioxide of chromium (Cr_2O_3)	35-50 per cent.
Alumina (Al_2O_3)	16-28 per cent.
Iron peroxide (Fe_2O_3)	17 per cent.
Silica (SiO_2)	4- 8 per cent.
Magnesia (MgO)	10-17 per cent.
Lime (CaO)	1- 2 per cent.

Chrome brick are well adapted to resist extremely high temperatures, though chrome iron ore is variable in composition.

Changing the Service of Direct-Current Machines

By Gordon Fox

SYNOPSIS—Directions for changing over a motor into a generator, and vice versa; also a discussion of the relative characteristics when operated under these conditions.

Occasions often arise making it desirable to utilize a direct-current motor as a generator, or *vice versa*. Most direct-current motors and generators are very much alike; the armatures and commutators are identical, the brushes are the same except as to setting, and the fields are similar. That the machines are interchangeable is shown by the fact that if two direct-current generators, *A* and *B*, are operated in parallel (driven from separate sources) and the engine driving *A* be shut down, its generator will run as a motor and draw current from generator *B*.

A motor is, in reality, a "counter electromotive-force generator." The armature rotating within the field poles generates a voltage less than the impressed voltage by an amount sufficient to allow the load current to flow. As the load increases the motor speed decreases, the counter electromotive force decreases and the current increases. A 230-volt compound-wound motor may have a counter electromotive force of perhaps 225 volts at no load and 215 volts at full load, the decrease being due partly to the drop in speed. Consider that the no-load speed of this motor is 900 r.p.m. and its full-load speed 850 r.p.m. If, instead of driving a mechanical load, the machine were driven at a speed of about 950 r.p.m. it would act as a generator, tending to generate more than 230 volts and pumping current out into the line. The armature IR drop must be subtracted from the line voltage to obtain the counter electromotive force of a motor but must be added to the line voltage to determine the generated electromotive force of a generator. Therefore, as a generator a machine must run faster than as a motor to operate at the same line voltage.

As a generator it is further desirable to have a little leeway for the use of the field rheostat. This necessitates a greater increase in speed to compensate for the slightly weakened field. Moreover, generator voltages are usually higher than motor voltages upon the same system because of the line drop. In general it may be stated that a motor must be driven about 10 per cent. above its speed rating in order to deliver rated voltage as a generator. Conversely, a generator used as a motor upon rated voltage will rotate about 10 per cent. below the speed indicated on its name-plate. These figures are at best only approximate, due to the wide range of characteristics of different designs.

In connecting a compound-wound motor for use as a generator the only change ordinarily required is the reversal of the series field connections. If this is not done the series field will buck the shunt field and the voltage regulation will be very poor. If the direction of rotation as a motor be unchanged, the machine will build up as a generator. If the rotation as a generator be opposite to that as a motor, then it becomes necessary to reverse the armature terminals in order to enable the generator to build up. If this is not done, the voltage generated in the armature through the action of the residual magnetism will cause the field coils to buck the residual effect rather than to aid it.

The external connections of a generator differ from those of a motor, in that the generator requires no starting resistance in series with the armature, but is provided with a rheostat in the shunt field circuit.

If a shunt motor be used as a generator it will not deliver a very satisfactory voltage. The purpose of the compound winding of a generator is to maintain the voltage or to cause it to increase under load. A shunt machine will drop in voltage from 5 to 15 per cent., under load, depending upon the design. The voltage can, of course, be regulated by manual control of the field rheostat. A compound-wound motor should be selected if possible where automatic voltage regulation is desirable. Standard motors are built for 20 per cent. to 40 per cent. compounding effect; that is, the series ampere-turns at full load are 20 to 40 per cent. of the shunt ampere-turns at rated voltage. The majority of over-compounded generators are designed for a voltage increase of about 10 per cent. under full load. This requires perhaps 20 per cent. series ampere-turns at full load, since generators are ordinarily operated above the knee of the saturation curve where the series ampere-turns are proportionately less effective. Therefore, a motor having 20 per cent. compounding is usually well adapted to run as a motor.

Since it is desirable to have some rheostat leeway for controlling the voltage, the shunt field will usually be worked at a lower density as a generator than as a motor, the deficiency in magnetic strength being compensated by increased speed. A low density at no load means that the compounding ampere-turns have greater effect. It will usually be found that a compound-wound motor adapted for generator service has an excess of compounding. This is a good fault inasmuch as it is an easy matter to shunt the series winding with german silver resistance and thus adjust its value as desired.

The full-load neutral, or best running, brush position for a motor is at a point shifted from the no-load neutral in a direction against that of rotation. In a generator the neutral shifts with the direction of rotation as the load is imposed. Consequently, if a machine be operated first as a motor and then as a generator, the rotation being unchanged, it is necessary to shift the brushes a considerable distance in a direction with the rotation. On the other hand, if the rotation be reversed, the original motor shift against the direction of rotation now becomes a generator shift with the rotation, and further change will likely be unnecessary. However, if, due to increased speed, the machine operates as a generator upon a weaker field than it had been running as a motor, the armature reactions will have an increased effect and a greater shift may be required.

An interpole motor is well adapted for use as a generator. If a compound motor is not available the interpole motor is its best substitute, since the action of the interpoles can be utilized to some extent in securing the voltage regulation desired. The interpoles of a motor have the same polarity as the main poles preceding them in a direction against the rotation. The interpoles of a generator have the opposite relation, being of the same polarity as the main poles following, in a direction with the rotation. When an interpole motor is changed over into a generator the relative polarity of the armature and the interpole must be reversed. One armature terminal is usually connected permanently to one interpole terminal. In making the change it is necessary to reverse this connection, using the other interpole terminal and the same armature terminal.

One cause of the dropping off in voltage of a shunt generator under load lies in the armature reaction. Since the interpole neutralizes armature reaction, it tends to thus better the voltage regulation. The regulation of an interpole generator can be further improved by giving the brushes a slight shift off neutral in a direction against the rotation. This procedure is in a way similar to shifting the series winding of the interpole over to the following main pole. The magnetizing effect of the interpole assists the main poles, increases their magnetism under load and, therefore, tends to maintain the load voltage and to improve the regulation.

It is obvious that the procedure for changing a generator into a motor is the exact reverse of that for changing a motor into a generator.

When the Gas Engine Will Not Start

By E. N. Percy

SYNOPSIS—Directions for systematically following up the trouble when an engine refuses to start; and, after having located the trouble, suggestions for remedying it.

When a gas engine refuses to start, there is usually one of two things wrong—the mixture or the ignition. It is best to test out the ignition first because it is easy to determine definitely if the trouble is from this source. First, test the battery by short-circuiting it with a piece of wire and note if a fat spark is obtained when the wire is snapped across the terminals. All engines with electric ignition have a timing commutator, regardless of the system used. Therefore, turn over the engine to a firing point, and if high-tension ignition is used the buzzer on the coil should sound. If it does not, it is probably out of adjustment or the spark-plug points need going over with a fine file or piece of emery paper. The adjusting screw should then be turned carefully back and forth until the buzzer begins to sound.

After the buzzer is working, place a screw-driver on the cylinder head and tip it until within about $\frac{1}{16}$ in. of the spark plug. If no spark jumps across from the top of the plug to the screw-driver, the indications are that either the plug is foul and the points short-circuited, the connection is broken, or the high-tension cables are leaking sparks onto the frame somewhere. The farther the spark jumps the stronger the battery.

One of the most baffling troubles is a weak battery. This may comply with the usual tests without giving indications of troubles, yet the spark will not be hot enough to ignite the mixture in a cold engine, although it may have been working well when the engine was shut down. For this reason, it is wise to use batteries only for starting, after which a generator or a magneto should be switched on.

Engines having make-and-break ignition should be tested in the same way, so far as the timer is concerned, but there is no buzzer. Instead, a screw-driver or piece of wire is snapped across the wire connection on the make-and-break plug, the other end of the wire being in contact with the engine cylinder. If a fat spark is had in this way, the igniter may be removed and snapped by hand, to see if it sparks. The wire should then be connected, and the ground side of the igniter should touch the iron of the cylinder. Care should be taken that the mixture in the cylinder is not ignited, or the operator may get burned. The make-and-break plug may now be returned to the cylinder and the adjustment examined. In this connection it should be remembered that the spark is made when the electrodes separate—not when they come together—and the quicker they separate, the better will be the spark. For this reason, slow-speed engines must have a snap-off mechanism for a make-and-break spark, while a high-speed engine can get a good spark from an igniter connected directly to a cam rod, without a snap-off mechanism.

Having determined that the trouble is not with the ignition, or having fixed such trouble as may exist, and still not being able to start the engine, it becomes necessary to investigate the mixture. If the engine is operating on gas of any kind, there is an excellent method of getting the right mixture into the cylinder. Let the air and gas be set as nearly correct as possible under the circumstances; then draw in a charge by turning over the engine by hand, and compress it slightly. Open a cylinder pet-cock slightly and apply a match. If the flame is smoky, there is too much gas in the mixture; if it is hard to light, there is not enough gas, particularly if the flame is colorless. If the flame is a clear blue or silver, the mixture is about right and should ignite. In fact, it may ignite by striking back into the cylinder through the pet-cock, but no harm will be done, except to move the piston slightly. If there is much compression the mixture may blow out of the pet-cock so hard that it will be difficult to light it.

With carbureting engines, this same plan is successful, but is attended with risk of fire, because of the tendency of liquid fuels to collect around the engine, their vapors greatly increasing the risk. In this type of engine trouble may be expected in starting in cold weather. To make certain of starting easily, fill the jackets with boiling water, if possible, and prime each cylinder with one squirt of gasoline, and fill the inlet pipes with air saturated with gasoline. If the engine still refuses to start, take out the spark plugs and drop a lighted match into the cylinder, first making sure that there is nothing in the vicinity to take fire. The cold gasoline in the cylinder will explode and rush out of the spark-plug hole with a roar, and the operator must be careful not to get too close. This is practically the only remedy for a flooded cylinder, except to laboriously turn over the engine until it is dried out.

Many of the cheaper engines have no carburetors, but merely a valve which lets the fuel into the inlet pipe, and some rough device for controlling the air. They frequently give trouble in starting, no matter how familiar the operator becomes with them. The best way to start such an engine is to have the fuel shut off, prime the cylinder, and squirt fuel over the inside of the inlet pipe. The engine will then start, and run for several revolutions, during which the fuel valve may be opened until the operation is regular. The reason for this is that this type of fuel valve usually floods the engine when starting, and a flooded cylinder is decidedly troublesome.

Unless an engine is badly flooded, it will start on most any kind of a mixture, but will not run long, nor will it develop much power unless the mixture is just right. Find out first where the adjustments are, then start the engine by priming, and after it is going, feed it with the squirt can with one hand and adjust the carburetor with the other, until it is fairly under way. Then, when under load, make the adjustments that seem to do the work best. If black smoke is given off, the mixture is too rich. This should not be confused with blue smoke which comes only from an excess of lubricating oil. There is usually a small excess of oil in the crank case when the engine is first started, and for this reason the supply of lubricant should not be cut down unless the smoke continues for some time. When the engine misses, and "coughs" back into the carburetor or inlet pipes, the mixture is too lean, and more fuel is required. The greatest economy is secured by using the thinnest mixture that will carry the load reliably. Mixtures rich enough to smoke are weak, not strong. The strongest mixture has been found to be that which contains a little more air than necessary to properly burn the fuel.

There are some two-stroke-cycle engines, mostly small, that are perfect mules of obstinacy when being started. The reason is that after the fuel is carbureted it does not go into the cylinder at high velocity, as in a four-stroke-cycle type, but is first detained in a cold crank case, where the fuel condenses, and air or a very lean mixture goes to the cylinder. Also, many of these engines have gauze in the inlet port to prevent backfiring into the crank case. This gauze, when cold, condenses much of the fuel, and it becomes necessary to prime the cylinders in starting, but it is equally important to refrain from flooding them. A good method is to draw off all the lubricating oil from the crank case and replace it with oil which has been heated until it smokes. This will usually heat the engine enough to start easily, as the cylinder does not have to be particularly hot if the crank case is hot enough to keep it from condensing the fuel.

In starting a cold engine, it pays to take the trouble to heat it up by one of the methods suggested, for after such treatment it starts so easily, provided the ignition is all right, that the uselessness of tugging and straining is apparent. The writer has seen engines of 40 or 50 hp. started by pouring a tea-kettle of hot water into the jacket of one cylinder. Those that give the most trouble are of the cheap factory type, without adequate carburetors or reliable ignition, yet they are used extensively in contracting work, agricultural machinery, and general small power work. The gas or gasoline engine is just as reliable as the steam engine, provided it is made equally well and receives equal attention and study.

There are now many devices and systems for making these engines self-starting. These systems, as a rule, are reliable, but a man must know his engine just the same, and be able to know that it is in condition to start, before he risks using up the power stored by the self-starter for that purpose.

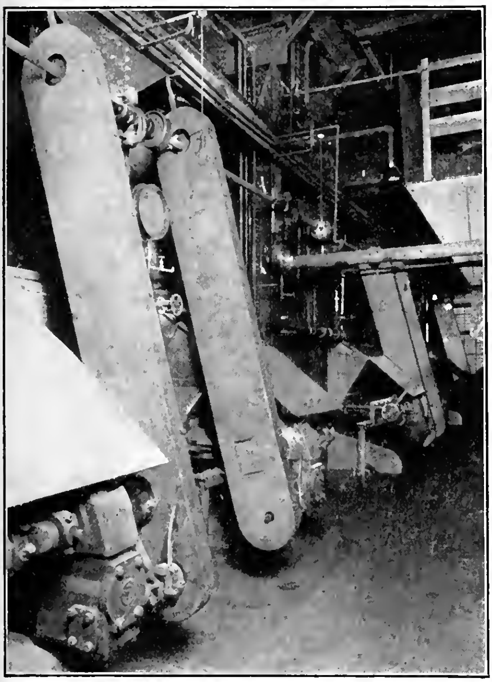
Comparative Tests of Stoker- and Hand-Fired Boilers

By H. S. Knowlton

Through the courtesy of the engineering department of the Norton Co., Worcester, Mass., the following test data are given, showing the comparative efficiency of hand and stoker firing in the boiler plant of this concern at Barbers Crossing. This plant was recently equipped with self-dumping, underfeed stokers, which are comparatively new in the field of power-plant equipment. The figures given are among the first to be published upon their operation. Their most striking features are: In place of stationary dead plates are moving, air-supplying grates, carried by the reciprocating sides of the retorts; moving overfeed grates extending across the entire width of the stoker, and pusher noses with ash-supporting plates for continuously dumping the refuse. This is the only type of underfeed stoker having live grate surfaces and the continuous automatic dumping of refuse.

As shown in the illustration, the Norton installation consists of a set of three-retort units per boiler, the steam-generating equipment of the plant having five 300-hp. vertical fire-tube boilers. The stokers are chain-driven from a fan shaft carried along the boiler fronts, the fan being located in the engine room to enable it to be under the eye of the engineer, besides furnishing a means of exhausting air from the engine room and aiding in the ventilation. The fan is 5 ft. 6 in. diameter, with three-quarter housing, and is driven by a 7x6-in. vertical inclosed engine, the maximum speed being 150 r.p.m. The fan discharge to the stoker air chambers is through a concrete duct in the floor with a maximum cross-sectional area of 1720 sq.in., each stoker being supplied through an 18x18-in. branch duct, while the cross-section of the main duct is diminished accordingly at each boiler. The fan speed is automatically controlled by the boiler pressure.

The boilers are fed with water by a centrifugal pump with a capacity of 90 gal. per minute, the pump being direct-connected to a 20-hp., 440-volt induction motor running 3600 r.p.m. This is about the smallest size of



View of Boiler Room of Norton Co.'s Plant

centrifugal feed pump capable of being operated at good efficiency, in view of the limitations of water passages. It is estimated that the steam consumption of the boiler-feed equipment of the plant has been cut in half by the installation of the motor-driven pump.

A fuel bed about 2 ft. thick is maintained on the grates, and above each set of retorts is a hopper containing 750 lb. of coal.

At a coal cost of about \$4 per ton, the equipment of the five boilers of the plant will pay for itself in about two years.

In analyzing the tests the Norton company points out that they represent an average taken from daily practice. While the hand firing is not all it should have been, the stoker eliminates all chance of carelessness likely to arise in a plant of moderate capacity not equipped with recording instruments maintaining a constant check on the fireman. The company has had but one stoker in operation continuously for about a year, and in that time has had no expense for repairs. The design of the working parts seems well balanced, as no weakness has so far developed. The capacity of the stokers has not as yet had to be tested, but the company is of the opinion that, if necessary,

TEST DATA

Boiler No.	1	3
Type of firing	Stoker	Hand
Date	May 14, 1914	June 16, 1914
Time	7 a.m. - 6 p.m.	7 a.m. - 6 p.m.
Duration	10 hr.	10 hr.
Average temperature feed water	179 deg.	157 deg.
Average gage pressure	142 lb.	142 lb.
Coal burned	8690 lb.	8470 lb.
Ash	720 lb.	790 lb.
Per cent. ash by weight	8	9
Water fed	97,200 lb.	80,774 lb.
Quality steam, assumed	Dry	Dry
Water evaporated per lb. coal fired	11.2 lb.	9.53 lb.
Equivalent evaporation per lb. coal	12.2 lb.	10.57 lb.
Per cent. CO_2	10.8	7.6
Per cent. CO	0.3	0.3
Heating surface	3444 sq.ft.	3324 sq.ft.
Grate surface	35 sq.ft.	42 sq.ft.
Evaporation per sq.ft. heating surface per hr.	2.8 lb.	2.4 lb.
Evaporation per sq.ft. grate surface per hr.	277 lb.	192 lb.
Coal burned per sq.ft. grate surface per hr.	25 lb.	20 lb.
Flue temperature	401 deg. F.	473 deg. F.
Per cent. combustible in ash	12.42	Not determined
B.t.u. per lb. coal as fired	14,600	14,600
Relative efficiency, per cent.	81	70

EQUIPMENT IN CONNECTION WITH TEST

Equipment	Manufacturer
Boilers, "Manning"	D. M. Dillon Steam Boiler Works
Stoker, "Riley"	Sanford Riley Stoker Co., Ltd.
Centrifugal feed pump	De Laval Steam Turbine Co.
Draft fans	B. F. Sturtevant Co.

it could push the boilers much beyond their rating. It is now doing with three boilers what formerly required four. This is due to the ease with which the boilers can be maintained at full rating and better efficiency. When the coal-hopper installation is complete, with facilities for overhead gravity delivery of fuel, it is expected that one fireman will handle five boilers, whereas under the old methods of hand firing two men were required.

The Storage Battery is composed of three fundamental working elements, namely, the positive plate, the negative plate and the electrolyte. There are several processes used in the manufacture of the plates, but the one most generally employed consists in making the positive elements of lead peroxide (PbO_2) and the negative of sponge lead (Pb). The electrolyte consists of sulphuric acid (H_2SO_4) diluted with water (H_2O). The active materials are held in their respective positions by lead grids.

There are various theories in regard to the chemical reactions which take place in a storage cell, but the one most generally accepted is that the passage of the current upon discharge causes the acid to react upon the active materials of the plates, forming in their places lead sulphate ($PbSO_4$), the reaction being accompanied by a reduction of part of the acid and the formation of water in its place. This is the cause of the decrease in the density of the electrolyte observed upon discharge. The chemical formula expressing the reaction at the positive plate upon discharge is

Lead Peroxide + Sulphuric Acid = Lead Sulphate + Water + Oxygen

$$PbO_2 + H_2SO_4 = PbSO_4 + H_2O + O$$

That of the negative plate is

Sponge Lead + Sulphuric Acid = Lead Sulphate + Hydrogen

$$Pb + H_2SO_4 = PbSO_4 + H_2$$

Upon charging, the current is passed through the battery in the direction opposite to that of discharge, with the result that the reactions expressed in the foregoing equations are reversed. The lead sulphate is reduced, the active materials—lead peroxide and sponge lead—are restored to their respective plates and the acid taken from the electrolyte on discharge returns to it, the water previously formed disappearing. This replenishment of the electrolyte causes the rise in density observed upon charging.

Forty Years' Advance in Steam Power Units

SYNOPSIS—Comments on the accompanying graphical comparison of the Centennial Corliss engine with a turbine of the same power, showing its relative size, and a turbine of the same size, giving its relative power.

In the account given of the Panama-Pacific Exposition in last week's issue reference was made to the big Corliss engine which was a feature of the Centennial Exposition at Philadelphia in 1876. This was in connection with an outline of the advance which has been made in steam prime movers since that day. The accompanying page illustration shows this progress of forty years graphically and gives briefly some of the more important data respecting the three units shown. The story is not complete in that it leaves out the chain of steps in the evolution, but it was not the purpose to portray this. Rather was it the intention to contrast and compare the old Centennial engine with the turbine form of prime mover, which is generally adopted today where large power capacities are desired in the space allotted.

Directly beneath the Corliss engine is shown a turbine of equivalent power, reproduced to the same scale in order to compare the relative sizes of the two machines. In other words, they are shown as the two machines would actually appear when viewed at the same distance from the observer. At the bottom of the page is shown, also to the same scale, another turbine, the largest at present in operation. The comparison of spaces required by the three units is unfair to the turbines in that they are complete electric generating units, whereas the Corliss engine shows only the steam end, its output being purely mechanical energy—for direct-connected steam-electric units were unknown at that time.

In the article of last week mention was made of the manner of distributing the power from the Centennial engine through an elaborate system of shafting with both gear and belt drives. This needs no repetition for the present purposes, but more in detail is in order concerning the engine itself, which will include some of the principal facts already given.

The Centennial engine had its cylinders and means of connection with the single flywheel, in duplicate, so that it was strictly a pair of beam engines, although connected as one unit. George H. Corliss, of Providence, R. I., was the inventor and manufacturer. The engines were designed to work expansively, with steam at an initial pressure up to 80 lb. The valves and valve gear were Corliss type with several improvements specially designed for and first applied to these engines. The cylinders were 40 in. diameter and the stroke 10 ft. Each of the beams was 27 ft. long by 9 ft. deep and weighed 11 tons. The flywheel, to the shaft of which the engines were connected at right angles, was a cut-gear wheel 30 ft. in diameter by 2 ft. face width and weighed 56 tons. It made 36 r.p.m., giving a piston speed of 720 ft. per min.

The pinion which the flywheel drove was 10 ft. diameter and weighed $8\frac{1}{2}$ tons. This rotative speed is in marked contrast to that of both the turbines, which is the big factor in accounting for the disparity of sizes between the two types of machine. It is a fundamental law that the power developed increases as the speed so, naturally enough, increasing the speed a hundred times means a greatly reduced size of prime mover.

An interesting comparison, if it could be made, would be that of steam consumption per horsepower-hour, but unfortunately Mr. Corliss would not allow the figures to be given out for his engine, if indeed they were ever determined by test; but doubtless a better economy would have been shown by the Centennial engine in spite of the lower steam pressure used, the absence of superheat in the steam, and the use of live steam in the cylinder jackets. The engine developed 1400 hp. and could be driven up to 2000 hp. when required. The platform on which the engine stood was 55 ft. diameter, or 2376 sq.ft. area, so that it is fair to consider this as the floor space occupied. The total height was 39 ft. and the total weight 700 tons.

Striking by contrast are the figures for the turbine of the same power shown beneath the engine. As before stated, it runs at 100 times the speed, or 3600 r.p.m., but it occupies only $\frac{1}{20}$ the floor space, or 119 sq.ft., and weighs about $\frac{1}{32}$ as much (22 tons). Its height is less than $\frac{1}{5}$ as great (7 ft.), but it uses nearly twice the steam pressure (150 lb.). The turbine shown in this instance is of the Curtis type, as built by the General Electric Co., rated at 1000 kw., which is very nearly the equivalent of 1400 hp. If anything, the turbine is more powerful than the engine, for the brake horsepower developed by the turbine would be more, there being some loss in the transformation to electrical energy through the generator.

The picture at the bottom of the page is that of the 30,000-kw. so called cross-compound Westinghouse-Parsons type turbine built by the Westinghouse Machine Co. and the Westinghouse Electric & Manufacturing Co. for the Interborough Rapid Transit Co.'s Seventy-Fourth St. station in New York City.

In some ways it makes a better type to compare with the engine, for it is also practically two machines and occupies very nearly the same floor space—51 by 40, or 2040 sq.ft. Therefore, whereas in the first case the Centennial engine was compared with a turbine of the same power, here it is compared with one of the same size and, incidentally, nearly the same weight—900 tons. The power, even allowing for no losses between the turbine and its generator, is seen to be nearly 29 times as great (40,200 hp.), the steam pressure $2\frac{1}{2}$ times as much (200 lb.) and the speed of the high-pressure rotor 42 times as much (1500 r.p.m.) and that of the low-pressure rotor 21 times as much (750 r.p.m.).

The use of two speeds is a notable advance in the design of this form of prime mover. To get the most suitable blade speeds for both the high-pressure and the low-pressure steam in elements all on one shaft and avoid severe stresses, involves mechanical difficulties. Using a high speed for the high-pressure element and a slow speed for the low-pressure overcomes these difficulties.

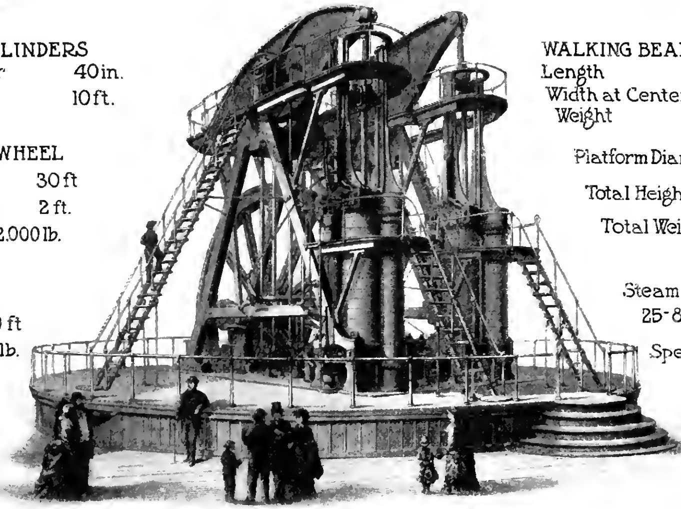
1876 DEVELOPMENT OF STEAM-POWER UNITS 1915

THE ILLUSTRATIONS ARE ENGRAVED IN THE SAME RELATIVE PROPORTION AS THE DIMENSIONS OF THE UNITS

CYLINDERS
Diameter 40 in.
Stroke 10 ft.

GEAR FLYWHEEL
Diameter 30 ft
Face 2 ft.
Weight 112,000 lb.

PINION
Diameter 10 ft
Weight 17,000 lb.



WALKING BEAMS
Length 27 ft.
Width at Center 9 ft.
Weight 22,000 lb

Platform Diam 55 ft.

Total Height 39 ft.

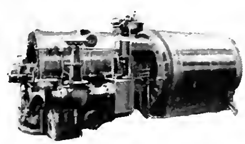
Total Weight 1,400,000 lb.

Steam Pressure 25-80 lb. per sq. in.

Speed 36 r.p.m.

The 1400-hp. CENTENNIAL CORLISS ENGINE of 1876

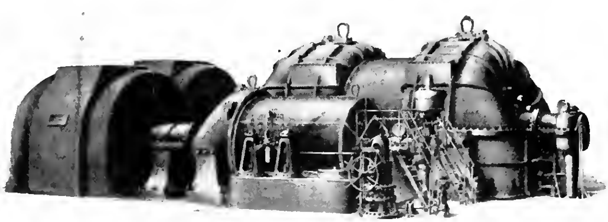
Length 17 ft.
Height 7 ft.
Weight 44,000 lb.



Steam Pressure 150 lb. per sq. in.
Speed 3600 r.p.m.

A 1400-hp. CURTIS-TYPE TURBO-GENERATOR of 1915

Length 51 ft.
Height 13 ft.
Weight 1,800,000 lb.
Steam Pressure 200 lb. per sq. in.



SPEEDS:
High-pressure Rotor 1500 r.p.m.
Low-pressure Rotor 750 r.p.m.

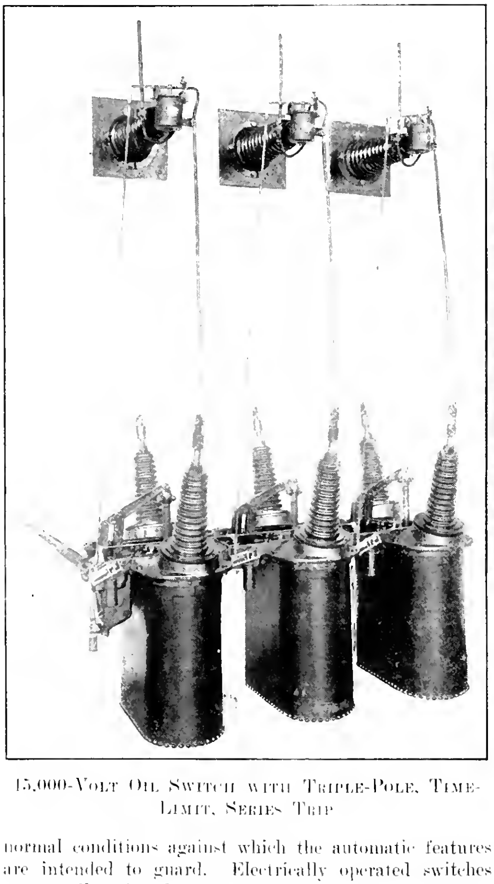
A 40,200-hp. PARSONS-TYPE TURBO-GENERATOR of 1915

In addition to the dissimilarity dimensionally, there is not the slightest resemblance in form between the machines at the bottom and top of the page, yet within a period of forty years both have been designed to perform the same work—to convert the heat energy in steam into work.

Some of the advantages which the later form has over the earlier have been mentioned. Another is its ability to use steam at very low pressures, say 26 to 29 in. vacuum. The reciprocating engine becomes prohibitively unwieldy when it carries the expansion of steam into a very high vacuum, and the excessive condensation offsets the desirability of low exhaust pressures. That is when the turbine as a coworker with the engine comes in, and in the future we shall probably see more and more of the combination units—reciprocating engines exhausting into steam turbines. Thus are the rivals becoming partners.

New Series Trip for High-Voltage Oil Switches

Low-voltage current is usually employed to trip high-voltage automatic oil switches on the occurrence of abnormal conditions against which the automatic features are intended to guard. Electrically operated switches are usually tripped by direct current, and for tripping hand-operated switches alternating current is generally used. In many instances, however, neither low-voltage direct current nor alternating current is conveniently or cheaply available, in which case automatic protection is secured by the use of a high-voltage series trip.



15,000-Volt Oil Switch with Triple-Pole, Time-Limit, Series Trip

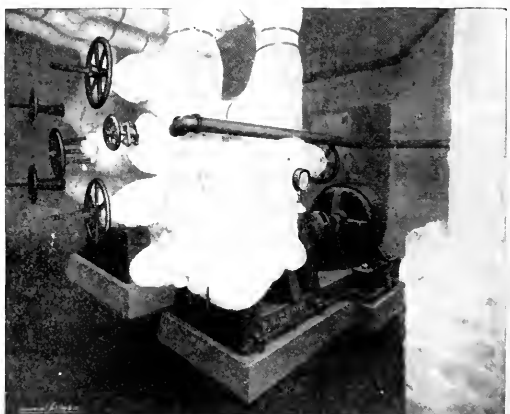
For this service the General Electric Co. has developed an arrangement representing an improvement on types of high-voltage series tripping devices heretofore in use. The new features are accessibility of the working parts for inspection, cleaning or adjustment while in service, without danger; calibration at the oil switch itself and not at the insulator supporting the series tripping solenoid; and the use of a new type of solenoid, consisting of a few simple and rugged parts that need practically no attention after installation.

The solenoid plunger is connected to the tripping mechanism of the oil switch by a wooden rod. Calibration, that is, change in current tripping values, is accomplished by a movable weight located near the operating mechanism of the switch, at a considerable distance from the high-voltage current.

This type of series trip is furnished for instantaneous or inverse time-limit operation. Time delay is obtained by means of a dashpot mounted on the tripping mechanism at the switch.

Good Service from Brine Pump

The illustration shows two brine pumps at the plant of the Independent Packing Co., Chicago. One of these units has been working 24 hr. per day for nearly a year without a stop for repairs. Covered with four to five inches of ice, it has run continuously at about 900 r.p.m. against a head of 20 lb.



The Pump Heavily Frosted

The pump is of the two-stage, all-bronze centrifugal type, made by the American Well Works. It has a capacity of 500 gal. per minute and is driven by a variable-speed direct-current motor. When starting the brine through the system, the pump requires about 27 hp. The speed is boosted to 1300 r.p.m. and the head is about 80 lb. When the brine is in circulation, the speed is lowered and only about 8 hp. is required to drive the pump. The second unit is held as a reserve, as there is danger of freezing the system.

Editorials

The Most Suitable Firebrick

The need of adapting the fuel to the furnace and *vice versa* has long been recognized. Adapting the refractory lining of the furnace to the temperature ranges and character of fuel is, at most, meagerly practiced, if at all in boiler work. It is common to line the furnace with one kind or grade of refractory material, yet the brick in contact with the fuel and ash is subjected to conditions never imposed upon that above the fire line. The latter is exposed chiefly to high temperatures only, while that below, besides being highly heated and carrying the load due to the weight of the brick above, is subjected to the chemical influences of the slag of the fused ash. Clinker tends to stick to the brick. When hit with a bar to loosen it, the brick is usually broken away where the clinker joined.

It would seem worth while, as pointed out on page 297, to use in most plants a highly refractory, tough, nonfrittering though expensive brick for that part of the furnace lining below the fire line, while a cheaper grade could be used above. The coal that will give the greatest number of pounds of water evaporated per unit of cost is best for the plant. Should not the refractory material that will give the longest service per unit of area or volume per unit of cost under the existing furnace temperature ranges be most suitable?

Synthetic Fuel

Fuel is capable of producing energy because it has the capacity of combining chemically with something, the union producing heat. The rise in temperature is simply an increase in the velocity with which the molecules move.

If a weight is in contact with the earth it has no inherent energy with respect to the earth. It cannot fall. Place it at an elevation, and it has potential energy which it can exert in other forms, as does the hammer of a pile driver or the weight of a clock.

The atoms of carbon and hydrogen in fuel attract, and are attracted by, atoms of oxygen, as the earth and the weight attract each other. When this attraction is sufficient, as in the furnace, to overcome the existing arrangement they rush together, gathering velocity and momentum, as does the weight falling to the earth. They do not impact and lose this velocity, as do the weight and the earth in overcoming the resistance of yielding substances or setting up molecular vibration at the point of contact (the heat of impact), but vibrate about each other like miniature planetary systems, with a vastly increased velocity. Their temperature is a function of this velocity and their mass; a measure of their momentum.

When they come in contact with the molecules of the boiler plate they set them into more active vibration, and this vibration is passed on to the molecules of the water, inciting them to such rapidity of motion that they break away from each other and fly off, like stones from a sling-shot, impacting upon the walls of the containing vessel and producing by their bombardment that which we recognize as pressure.

The gases, cooled (having imparted a part of their velocity or momentum to the atoms of the heating surface), pass off to the atmosphere. They are in the condition of the weight and the earth which have come together; the clock which has run down. They cannot get up any more velocity or momentum in themselves by falling any closer. How, then, are they to be separated that they may be again available as media of energy?

When the carbon combines with the oxygen they form carbonic-acid gas, the gas which makes the bubbles at the soda fountain and gives the sparkle to wine. When hydrogen combines with oxygen they form water. To decompose the carbonic-acid gas or the water, that is, to dissociate these molecules into atoms of carbon or hydrogen and oxygen, takes as much energy as is generated by their combustion or coming together.

And here comes in one of the most wonderful, beautiful and mysterious of Nature's processes, described in this way in an old school chemistry, the name of the author of which we do not recall: It is a peculiar property of vegetation that under the influence of sunlight it can overcome the attraction which exists between the atoms of carbon and oxygen, appropriating the carbon to its own use, building it into its structure, and letting the oxygen go free into the atmosphere. To separate these elements in our laboratories, we are obliged to resort to the most powerful chemical agents and to conduct the process in vessels composed of the most refractory material, under all the violent manifestations of light and heat; and we then succeed in liberating the carbon only by shutting up the oxygen in a still stronger prison. But under the quiet influence of the sunbeam, in that most delicate of all structures, a vegetable cell, the chains which unite together the two elements fall off, and while the solid carbon is retained to build up the organic structure, the oxygen is allowed to return to its home in the atmosphere. To separate a pound of carbon from the oxygen with which it unites in burning would require the expenditure of an amount of energy which would raise the weight of a ton to a height of over a mile, and yet, in the economy of Nature, this process is constantly going on, not with the noisy demonstration of prodigious effort, but quietly, in the delicate structure of a green leaf waving in the sunshine.

The most promising direction in which to look for a more direct or rapid process than that of waiting for fuel to be produced by the slow growth of vegetation is through the discovery of the secret of the vegetable cell, and the application of the sun's energy either to the direct production of other forms or to the synthetic production of fuel. At a meeting of the French Society of Civil Engineers some time since, M. Daniel Bertholet said that, working in conjunction with M. Gaudechon, he had succeeded in producing the principal sugars by acting with ultra-violet light on a mixture of gaseous carbon dioxide and water. In a further set of experiments compounds of carbon, oxygen, hydrogen and nitrogen were produced by acting with these ultra-violet rays on a mixture of carbon dioxide and ammonia. In these conditions the carbon dioxide is decomposed just as it is by chlorophyll under the action of sunlight. Activity in this direction would be much more promising than that in the direction of the fuel mixtures, of the rise and decline of which so much has recently appeared in the public prints.

Keeping Track of Plant Operation

Plant revenue is derived from plant output, but for many years the switchboard output was the only thing about the plant that was metered except where the local authorities applied a water meter to the service pipe. Of course, the monthly payroll, repairs and the cost of fuel, oil and supplies were recorded, and in a few cases the weight of the coal fired was noted. Occasional indicator diagrams were taken on the engines, and some plants were tested when new. Records along these lines were at one time considered the last word in refinement, although there were some who strenuously maintained that there was a big gap between the grate bars and the switchboard, where serious plant losses might occur undetected. One of the difficulties to be overcome in isolating these losses was the supposedly fragile nature of the instruments required and their unsuitability to the boiler room.

When the steam turbine came into general use in central stations the steam-engine indicator retired, and then there really was nothing between the grate bars and the switchboard to tell what was happening except the recording steam-pressure gage. The first instrument to become a factor in boiler-room operation after this was the CO_2 meter. This revealed many sources of leakage and expense without adequate return and put a premium upon complete combustion. The Orsat apparatus revealed high oxygen and checked the combustion recorder. Between these two lies the responsibility for a general advance in fire-room practice and the patching up of boiler settings. The disadvantage resulting from porous brickwork brought the marine type of setting to the attention of power-plant engineers, and sheet-steel casings are not uncommon in modern practice.

Extended experience, however, showed that there were still uncovered sources of waste. High CO_2 occasionally failed to be an accurate index of economy, particularly where a number of boilers were employed and premiums paid. Instances occurred where it took more boilers to carry the load than were absolutely necessary, or low steam pressure somewhere was revealed by an unexpected jump in the load curve. The investigation of uptake temperatures and draft pressures furnished a partial cure for the trouble, but the final check was the use of the steam meter and the feed-water meter.

Incidental to the introduction of these instruments came the close study of boiler settings, boiler output and the possible increase in power output, increase in grate area and large boilers. It took years for the metallurgical engineer to learn that the low-roofed furnace designed to force the heat into the bath by close contact with the flame was a mistake. He raised the roofs of his furnaces, gradually learning that the larger combustion chamber and the radiant heat resulted in economy of fuel and reduced roof repairs. Today the same lesson is being brought to the attention of those interested in boiler output along economical lines. The published tests of the Delray boilers and the tests and operating results secured in the new Cleveland municipal plant indicate what the boiler room can do.

License Legislation in Massachusetts

A new engineers' license law (House Bill 1111) is before the Massachusetts legislature and is occasioning a great deal of interest. It appears under the patronage of a voluntary committee, which has headquarters in the Sears Building, a secretary in the person of Richard B. Stanley, and representatives from the paper, pulp, cotton, woolen, metal-working, quarry and lime industries, and the boards of trades. The difference between the present and proposed laws is thus set forth by the propagandists:

PRESENT LAW	PROPOSED LAW
It recognizes no difference in the risk of operation between steam engines and steam boilers.	It recognizes much difference in the risk of operation between steam engines and steam boilers.
It fails to determine the scope of examinations and to require them to be uniform throughout the state.	It determines the scope of examinations and requires them to be uniform throughout the state.
It permits the requirement of knowledge of the principles of design in the examination of applicants for licenses to operate.	It limits to knowledge of operation the examination of applicants for licenses to operate.
It permits the requirement of knowledge of the principles of design of boilers in the examination of applicants for licenses to operate engines.	It limits to knowledge of engine operation the examination of applicants to operate engines.
It permits the examiner to require involved mathematical calculations, thereby denying employment to competent men.	It prevents the examiner from requiring involved mathematical calculations.
Complex and difficult to understand.	Simple and clear.

The bill appears, probably from oversight, to fail to forbid the operation of engines between twenty-five and one hundred and fifty horsepower without a licensed engineer, and is evidently designed to forestall any attempt to restrict the supply of available engineers and firemen by subjecting them to an impassable examination and to the requirement of a licensed man for everything about the power house from superintendent to coal passer.

Another bill (House Bill No. 19) puts into effect, if passed, the recommendations of the Chief of District Police with regard to the examination and certification of inspectors of boiler-insurance companies.

Some Dates to Remember

Dec. 15, 1912, Hall of Records Test begun.

Dec. 15, 1913, Hall of Records Test finished.

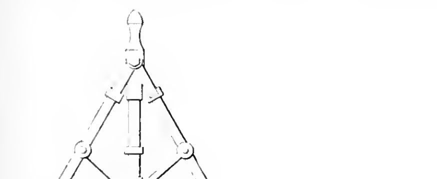
Mar. 2, 1915, Advisory board of engineers still debating.

Would fourteen months of silence have followed the conclusion of the test had the figures favored the New York Edison Co.?

Correspondence

Operating Refrigeration Plants Safely

At present there is much needed discussion of safety in refrigeration plants published in POWER. The use of safety valves does not meet with general approval, and there are several good reasons for this. After a safety valve has been set to operate at a certain pressure, say 300 lb., it may be a long time before the pressure from any cause will reach a point that will cause this valve to open. All ammonia plants are troubled with dirt, scale and chunks of litharge and it is almost impossible to clean these completely out of the piping system. Some of this foreign matter will be carried along with the escaping ammonia and deposited on the seat of the safety valve, preventing it from closing tightly, though it be of the best design. The idea of using a body of water as an absorbent has been completely answered by Mr. Fairbanks, of Boston (see POWER, Dec. 15, pp. 849 and 866), and the writer will not touch on that point here. The various laws of different states regulating the operation of steam boilers (notably those of Massachusetts, which some consider to be the best) are useless unless strictly lived up to. This is mentioned only to illustrate that, no matter what safety device may be ordered by law for the safe operation of refrigeration plants, that device will be of no avail unless it is of such design that it can be easily looked after and kept in good working order at all times.



AMMONIA PRESSURE RAISES THE GOVERNOR, GIVING EARLIER CUTOFF, THEREBY REDUCING THE COMPRESSOR SPEED

Investigation of numerous accidents to refrigerating plants has proved that a large percentage were due to the carelessness of someone operating the plant. The most destructive accidents may be summed up as those caused by excessive pressure from the loss of cooling water on the condenser, not opening the discharge valve from the compressor to the condenser after the former had been pumped out for packing the rod or other repairs, or from a heavy charge of liquid being carried over from the low-pressure side of the system, and in a lesser degree the breaking of a follower plate or a valve stem, which in either case must cause the destruction of the compressor regardless of any and all safety devices on the market.

I make it a practice to replace all suction valves that open into the compressor, after they have been in continuous use two years. This is done on the assumption that the constant hammering that they are subjected to must cause crystallization. In fact, I once broke a valve stem that had been, as near as I could learn, in continuous use about five years, by striking it a sharp blow with a small hammer. Within the past year one of our compressors developed a badly cracked follower. I mention these things to show that fatigue or weakening of parts is a cause of danger that cannot receive too careful consideration by owners and operators.

There are two devices for preventing an excess pressure being generated in a refrigeration system that have come under my observation. One consists of a small safety valve piped directly from the compressor cylinder, that discharges into a cylinder fitted with a piston, the crosshead of which engages the governor stem. When the pressure in the compressor cylinder exceeds a predetermined point, say 200 lb., the safety valve admits ammonia to the pressure-regulating cylinder, lifting its piston, which in turn lifts the governor spindle and disengages the hooks so that the steam valves cannot be opened by the valve gear, and the engine comes to a stop. This works well on a machine with one steam cylinder, as this device has no method of breaking the vacuum, as in a compound condensing machine. It is not as quick in action as the method now employed by the writer and which has given satisfaction for over six years. The refrigerating machine has an engine stop, and the ends of the ammonia compressor are piped to a pressure gage so designed as to permit the use of the pointer as an electric switch to close the electric circuit putting the engine stop in motion. This action closes the throttle and breaks the vacuum, stopping the machine in as short a time as seven seconds. The device is adjusted to operate at 200 lb., and in very hot weather, when the working pressure has been close to that point, it has been found impossible to keep the machines in operation until the head pressure had been lowered. The stop is also equipped with a remote control, with six stations located in different parts of the engine room and one general station outside the building, where, by breaking the glass and pulling down a lever, the power plant can be brought to a standstill. A system of this kind that prevents the generation of an excessive pressure in the refrigerating system is the best means of promoting safety in handling large quantities of ammonia.

In case of a fire that would be likely to destroy a building used for refrigeration purposes, there would be little choice between blowing the high-pressure ammonia from a pipe ten feet higher than the building and allowing the building to collapse, bursting the ammonia pipes. It is commendable practice to carry ammonia relief pipes to the top of the smoke-stack.

H. W. GEARE.

New York City.

Repairing Crack in Combustion Chamber

About two years ago a combustion chamber on one of our 1000-hp. gas engines cracked from top to bottom, a distance of about 14 in. This engine is used as an auxiliary and has not been run very much since then. When the crack first developed, the cylinder could be used by starting the engine with no water in the jacket, the crack closing by expansion due to the increased temperature and preventing the water from entering the cylinder. The opening seemed to become larger, however, and finally the cylinder could not be used at all.

At first it was thought useless to try to repair the break, but later, representatives of two welding firms were consulted. One agreed to weld the crack at an exorbitant figure, but would not guarantee the job; the other expressed the opinion that it could not be repaired.

After this I asked permission for a trial at repairing it, which was granted. I began the job with Smooth-On cement and 5/8-in. Norway-iron studs. The second hole was drilled so as to cut into one-third the diameter of the first, and so on all the way up the crack. The studs were screwed in with the iron cement, cut off and slightly peened. The repair proved successful.

J. B. LINKER.

Charlotte, N. C.

Starting a Small Motor

In the Jan. 12 issue Walter S. Griscom tells of difficulty in starting a small motor. This trouble was undoubtedly due to a weak field, which in turn, was probably caused by low voltage at the motor terminals, due to drop resulting from a long length of small wire or bad or loose connections. Such a drop will be aggravated by an increase in amperage, and a shunt motor under these conditions may have little field strength and possibly not enough torque to start the motor. Putting resistance in the armature circuit would partially overcome this difficulty, but I fail to see the necessity for leaving the lamps in circuit after the motor is up to speed.

Several years ago a motor-generator was set up and operated in our plant by a young fellow who didn't care to have anybody advise him. He was never able to start the machine without help and a careful manipulation of the starting box. The machine was later turned over to me, and I found that the connections on the starting box had been made so that the field was in series with the starting resistance. After changing this the motor started promptly.

I have also seen the experiment tried of electrically connecting two 50-kw. shunt-wound machines while idle, and attempting to bring both up to speed together, one acting as a generator and the other as a motor. The main circuit-breaker would invariably trip without noticeable indication on the voltmeters or without producing appreciable torque in the second machine.

H. L. STRONG.

Yarmouthville, Maine.

Who Gets the Promotion?

Concerning the Foreword in the issue of Dec. 15, 1914, and Mr. Farnsworth's deductions on page 172, issue of Feb. 2, 1915, I can see no reason for saying that only one of the men has made preparation for the position. Neither can I agree with him that the manager has no right to consider his own likes or dislikes in the matter. I think that any engineer will agree that he can do a whole lot better with a plant where he is on good terms with the boss than otherwise. A man who is popular with his mates will be more likely to have harmony among his men when he gets to be the chief than a man who is ill tempered, surly or just plain cranky. I say this from experience. Neither will they resent his authority as much as they would if he were a grouch. I have heard men say behind my back when I was foreman: "Yes, he looks and acts like a kid when he is playing with the boys, but when the whistle blows he knows how to handle his men, and if he tells you to do anything, you had better do it." I could skylark with the boys or men of my crew outside of working hours and maintain discipline among them when on duty, and I have the reputation of getting the best possible service from my men.

Because a man is grouchy, this does not unfit him for the position, but everything else being equal, the cheerful man will have more harmony and stand a better chance of success. Personally, I would feel more like doing my best for the man who would treat me like a chum than I would for one who would hardly say "Good morning" civilly.

If a man is steady, sober and honest, does it not count for many points in the promotion game? Of course, if these are the only points they are not sufficient, but if he has seen long service he must have acquired considerable ability. Of course, there are men who make good assistants but very poor chiefs, and the ideal chief is one who will combine the good qualities of all three; such men are born, however, not made, and this is the reason that we often see a young fellow installed as chief while his assistants are double his age and experience, yet lacking the knack of control.

However, all this does not help the manager to decide, but if I were in his place I believe I would choose the one with the cheerful temper if I liked him personally. I think being a hustler does not imply being always hurrying or on the run.

A. A. BLANCHARD.

Oxford, N. J.

Notes on Indicator Diagrams

While it is obvious that the indicator diagrams shown in POWER, Nov. 3, 1914, p. 650, are due to a slipped eccentric, it is not evident that the rod is out of adjustment. Granting that the diagrams were taken from an engine with a simple slide-valve, both adjustments are at fault. While the data given are not complete, it is possible to show that if the shaft were 4 in. in diameter, the engineer would need to lay off with dividers $2^{3}/_{64}$ in. and advance the eccentric that amount. For the engine in question this would need to be multiplied by the ratio of the diameter of its shaft to 4 in.

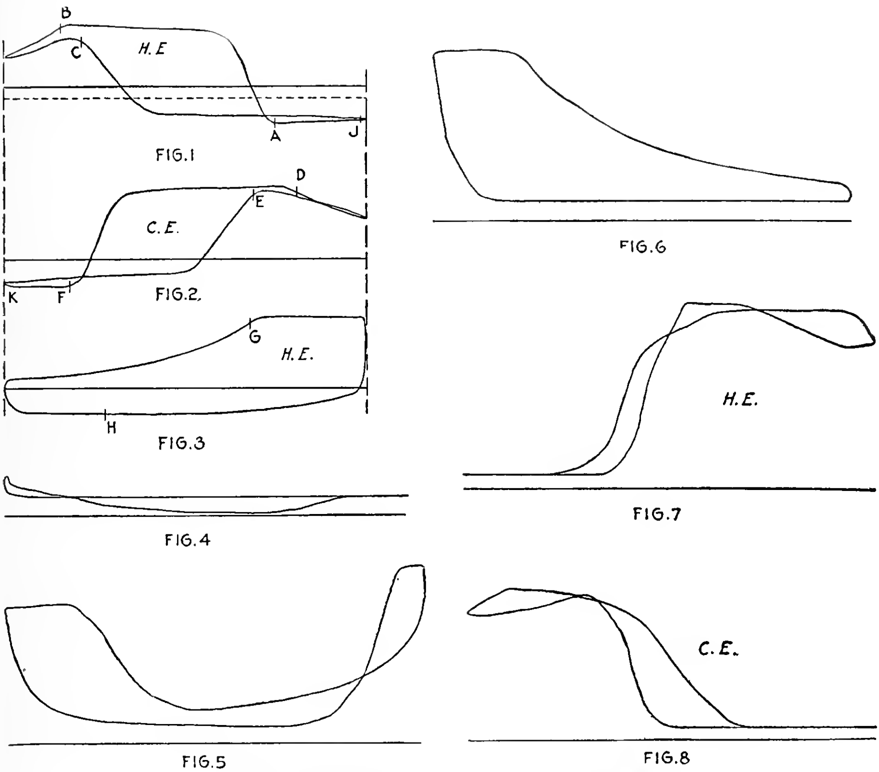
This is easily done graphically by drawing the shaft circle to scale and a 4-in. circle concentric with it. Lay off on the latter a chord as given and continue radial lines through its ends to the shaft circle. It would be easier in laying this out on the shaft to use two chords of $1\frac{1}{16}$ in. (on the 4-in. shaft) instead of one. This ratio is the scale factor of the diagram used to get the data given below. The rod should also be lengthened $\frac{3}{32}$ in. multiplied by this ratio.

Since no information is given regarding the compounding of this engine, no speculation has been made concerning the action of this low-pressure cylinder or the effect on the revised diagram. Figs. 1 and 2 show the original diagrams traced with events marked. Fig. 3 gives the card obtainable under favorable conditions with the correct setting as indicated, but with the same terminal pressures. In the original diagram, Fig. 1, the atmospheric line is about 5½ lb. too high. It should be where the dotted line is, though this does not affect the diagram so far as valve analysis is concerned. The crank-end diagram is similar.

	1	2	3
	Per Cent. Stroke		
Admission.	A - 25	F - 19%	Near dead center.
Cut off. .	B - 84	D - 81	G - 32%
Release	C - 78	E - 64	Near end of stroke.
Compression.	J - 2	K - 0	H - 72%

Interesting freak diagrams, Figs. 4 and 5, are from the head and crank ends of a 7¾x15-in. piston-valve engine, normal speed, 220 r.p.m. This 35-hp. engine was not running over 100 r.p.m. at the time the diagrams were taken. Fig. 6 is from the head end taken after setting the valves. The crank-end diagram is similar, though at this time it was not quite as perfect. Diagrams 7 and 8 were taken under similar circumstances from the same engine. This condition of the valves is one that might result from the breaking of an inner valve ring, where the ring caught between the two valves and slipped the rods and the eccentrics—an accident that has occurred on this type of engine.

To those interested in valve setting, these diagrams should claim attention, for to correct faults it is often necessary to locate all the events, though the action is complicated here by the relative movement of the two valves.



SOME RATHER PECULIAR INDICATOR DIAGRAMS

The valve gear is such that the main valve is indirect, as it takes steam on the inside, has a travel of 2⅜ in. and a nonreversing rocker. The eccentric is some thirty inches behind the crank.

The rider valve eccentric is about thirty degrees ahead of the crank when the governor is down and some ninety degrees ahead when running light. Its valve is also indirect, as its motion is reversed by a rocker pivoted at its center to the center of the main valve rocker. The valve takes steam on the outside and its travel, both relative and absolute, varies. The latter is about 3½ in. when the governor is down and may be from 4 to 4⅜ in. when carrying a load, varying with the load and with the setting.

Because of this variable valve travel a valve diagram does not represent the movements of the parts as well as it does for the simpler valve gears, such as the Meyer.

The results of a Zeuner diagram for the first two diagrams may be of interest. Taking, for convenience, a 4-in. valve travel and a connecting-rod five times the length of the crank, it is found that the events check as shown. For the final setting, which was made for $^1/_{64}$-in. lead on the head end and for equal cutoffs, we have the following:

End	Admission	Cutoff	Release	Compression	Steam Lap, In.	Dead, In	Port Opening Steam, In	Port Opening Exhaust, In
Head	0	32	99	72	$1\frac{11}{16}$	$\frac{1}{64}$	$\frac{5}{16}$	$\frac{3}{8}$
Crank	0 5	32	99	68	$1\frac{13}{16}$	$\frac{3}{16}$	$\frac{33}{64}$	$\frac{3}{16}$

These port openings are the maximum possible and must be compared with the actual ports to get under travel. All dimensions, except the percentages of stroke, must be multiplied by the ratio of the actual valve travel to 4 in.

A. R. NOTTINGHAM.

West Lafayette, Ind.

Stopping a Low-Pressure Complaint

The editorial, "The Wrong Slant," in the Dec. 15 number, calls attention to the status of the steam engineer in most factories. Besides being an "expense" he is often the "goat" for any accident that may occur which reduces the output of the factory. The power item being large in the production of some articles, the engineer is often held accountable for losses, and sometimes when he is in no way responsible. Even when he is not charged directly with the responsibility for losses, he is informed that the loss in department so-and-so was due to a drop in steam pressure or to a few minutes' interruption of light or power service, and this in a tone which leaves him with the impression that life is just one thing after another.

In a factory making food products, where much steam was used for cooking and drying, the foremen of the different departments seemed prone to charge their short or otherwise unsatisfactory outputs to a drop in steam pressure. This so got on the nerves of the master mechanic that he persuaded the manager to buy a recording pressure-gage. This was fixed to the wall above the master mechanic's desk and connected to the steam main in the boiler room, which was in the adjoining building.

A few days later the manager sent for the master mechanic and informed him that the output of Mr. Jones' department had been seriously reduced the night before on account of a great drop in the steam pressure. The master mechanic produced the chart taken from the gage at 7 o'clock that morning and showed that during the previous 24 hr. there had been no abnormal variation in the pressure and that the statement of Mr. Jones was just a plain lie. The manager must have had a heart-to-heart talk with Mr. Jones, because late in the afternoon Jones called on the master mechanic and had quite a lengthy but friendly chat. No reference was made to steam pressures, but Jones kept his eyes on the pressure gage throughout the conversation. As he was about to leave he pointed to the gage and asked, "What is that thing there?" "That?" said the master mechanic; "O, that's a trap to catch four-flushers."

C. O. SANDSTROM

Kansas City, Mo.

Quarter-Turn Rod Coupling

Under the above title, on page 117 of the Jan. 26 issue, there is reference to a device patented by C. P. Hall, of the Rookery Building, Chicago.

If my memory serves me rightly a coupling of this construction was designed by William G. Bond, chief engineer for the National Biscuit Co., Tenth Ave. and Fifteenth St., New York City, some fifteen years ago, and it may now be in service in that plant.

I was in charge of the electrical equipment and assisted Mr. Bond in the preparation of the working drawings of a coupling that I am almost positive was similar in every way to the detail you have shown.

NEWTON L. SCHLOSS.

New York City.

Grouting under Heavy Machinery

I have seen engine erectors use neat cement for grouting under engines. This, I believe, makes a grouting inferior to a mixture of one part cement and one part clean sand, or even two of sand to one of cement. While neat cement gets very hard, it cracks easily.

It is a matter of considerable discussion whether, in setting engines, the leveling wedges should be left in or taken out after the grouting has set. With the wedges in, almost the entire weight of the engine remains on them, as the grouting will not set up tight enough to take the weight and the engine is much more apt to work loose on its foundation.

I once had a three-cylinder vertical, direct-connected engine that worked badly. The engine was raised a quarter of an inch, the old grouting knocked out and some four hundred pounds of sulphur run under the base. Sulphur was used because the foundation had become so oil-soaked that it would have been impossible to get a cement grouting to bond. That job was done more than four years ago and the engine does not show the slightest movement.

In doing this work it was found that a wedge had been left under each side of the base at about the center of the engine. If these wedges had been pulled out in the first place, the engine would never have started working as it did; it was simply rocking on the wedges.

D. N. McCLINTON.

Pittsburgh, Penn.

Inquiries of General Interest

Rerolling of Boiler Tubes—When a return-tubular boiler has been in continuous use for five years, the tubes having been rerolled a number of times, is it possible to cut off the tube ends by further rerollings?

F. C. T.

If the boiler tubes are rerolled in such a manner that they are each time expanded inside of the tube sheet, then a sufficient number of rerollings will cause the tube ends to split or to break off, especially if the tube material has become weakened by corrosion.

Breakage of Shafts in Hubs of Pulleys—What reason is to be assigned for repeated breakage of our shafting inside of the hubs of driving and receiving pulleys?

J. O. B.

The shafts break in the hubs of the pulleys because those are the points where, mainly from tension of belts, the shafts are subjected to greatest bending stresses. The remedy is to reduce the bending stresses by placing bearings closer to the pulleys or using larger pulleys, thereby transmitting the same power with less belt tension and also less journal friction.

Relative Water Used by Refrigerating Systems—Is there any difference in the quantities of water required by absorption and by compression systems of refrigeration of like capacity?

G. B.

It is customary to use a little more water for absorption systems than for compression systems having simple steam engines. When compound condensing engines are used for driving compressors the water used to obtain 26 in. vacuum is about the same as required for a standard absorption system of equal refrigerating capacity.

Latent Heat of Fusion and of Evaporation—How many B.t.u. must be added to 1 lb. of ice at 32 deg. F. to melt it to water at the same temperature; and how many B.t.u. must be added to 1 lb. of water at 212 to convert it into steam at atmospheric pressure?

F. A.

The heat required to melt a pound of ice at 32 deg. to water at the same temperature is 144 B.t.u., this being the latent heat of fusion of ice. Conversion of a pound of water at 212 deg. F. into dry saturated steam at atmospheric pressure, requires the addition of 970.4 B.t.u., called the latent heat of evaporation at atmospheric pressure, one B.t.u. being taken as $^{1}/_{180}$ of the heat required to raise a pound of water from 32 to 212 deg. F.

Conversion of Gage Readings into Absolute Pressures—With a barometric reading of 29.4 in. what would be the absolute pressures corresponding to 100-lb. gage pressure and 26-in. vacuum?

C. R.

Assuming that the barometric and vacuum gage readings are, as usual, based upon heights of mercury columns at a temperature of 62 deg. F., at which temperature an inch of mercury column is equivalent to 0.491 lb. per sq.in., then for a barometric reading of 29.4 in. a gage pressure of 100 lb. would correspond to

$$100 + (29.4 \times 0.491) = 114.435 \text{ lb. per sq.in. absolute}$$

and 26-in. vacuum would correspond to

$$(29.4 - 26) \times 0.491 = 1.669 \text{ lb. per sq.in. absolute.}$$

Temperature of Steam at Reduced Pressure—If dry saturated steam at 85-lb. gage pressure is passed through a reducing valve what will be its temperature if reduced to 4-lb. gage pressure?

Q. W. D.

By referring to Marks and Davis' steam tables it may be seen that each pound of dry saturated steam at 85-lb. gage pressure, or 85 + 15 = 100 lb. absolute, contains 1186.3 B.t.u. above 32 deg. F. Neglecting the heat lost by radiation and in work overcoming friction in passing through the reducing valve, which under ordinary circumstances would be negligible, each pound of the steam at the reduced pressure of 4 lb. gage, or 4 + 15 = 19 lb. absolute, may be regarded as containing the same number of heat units as in the original condition, viz., 1186.3 B.t.u. above 32 deg. F. Referring to the same tables of heat of steam at various pressure and with different degrees of superheating, it is found that the temperature of dry saturated steam at 19 lb. absolute, when saturated, contains only 1155.2 B.t.u. per pound above 32 deg. F., and the temperature is 225.2 deg. F., but when superheated 60 deg. F. each pound contains 1183.6 B.t.u., and when superheated 70 deg. F. each pound contains 1188.3 B.t.u. The degree of superheat corresponding to 1186.3 B.t.u. is therefore found by interpolation to be

$$60 + \left[\frac{1186.3 - 1183.6}{1188.3 - 1183.6} \times (70 - 60)\right] = 65.7 \text{ deg. F}$$

and the actual temperature would be

$$225.2 + 65.7, \text{ or about } 291 \text{ deg. F.}$$

Efficiency of Boiler and Grates—What would be the efficiency of a boiler and grate if the evaporation of 37,968 lb. of water from feed water at 170 deg. F. into dry saturated steam at 110 lb. per sq.in. gage pressure required the combustion of four tons of coal of a calorific value of 13,000 B.t.u. per lb.?

V. K. S.

Each pound of feed water at 170 deg. F. would contain

$$170 - 32 = 138 \text{ B.t.u. above } 32 \text{ deg. F.}$$

and as a pound of dry saturated steam at 110-lb. gage pressure, or about 125 lb. per sq.in. absolute, contains 1190.3 B.t.u., then each pound of water evaporated into steam would require

$$1190.3 - 138 = 1052.3 \text{ B.t.u.}$$

so that under the conditions stated the evaporation of 37,968 lb. of feed water would require

$$37{,}968 \times 1052.3 = 39{,}953{,}726.4 \text{ B.t.u.}$$

Allowing 2000 lb. per ton, then in using four tons of coal the heat absorbed per pound of coal would be

$$\frac{39{,}953{,}726.4}{4 \times 2000} = 4994.2 \text{ B.t.u.}$$

As the efficiency of the boiler and grate would be equal to

$$\frac{\text{Heat absorbed per pound of coal}}{\text{Calorific value of 1 lb. of coal}}$$

the efficiency would be

$$\frac{4994.2}{13{,}000} = 38.41 \text{ per cent.}$$

Piston Speed Assumed in Pump Formula—What pump piston speed would have to be assumed for figuring pump capacity by the formula, Gallons pumped per minute = $d^2 \times 4$, in which d represents the diameter of water piston in inches?

K. H.

Without allowing for slippage or reduction of piston area by the piston rod, the delivery would be expressed by the formula:

$$(1)\quad \text{Gallons per min.} = \frac{d^2 \times 0.7854 \times L \times n}{231}$$

in which

d = Diameter of water piston in inches;
L = Length of stroke in inches;
n = Number of single strokes per minute;
231 = Number of cubic inches per gallon.
Calling S = Piston speed in feet per min., then as

$$S = \frac{L}{12} \times n \text{ or } 12\,S = L \times n,$$

formula (1) might be written

$$(2)\quad \text{Gallons per min.} = \frac{d^2 \times 0.7854 \times 12\,S}{231} = d^2 \times 0.0408 \times S$$

Therefore, the given formula would be true when

$$d^2 \times 4 = d^2 \times 0.0408 \times S,$$

i.e., when S = 98.04; or, in other words, the given formula would be correct for an assumed piston speed of 98.04 ft. per min. without any allowance for slippage or piston rod, which would be equivalent to assuming a piston speed of 100 ft. per min., with an allowance of

$$\frac{(100 - 98.04) \times 100}{100} = 1.96 \text{ per cent.}$$

reduction of capacity by slippage and piston rod.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

The Effect of Vacuum in Steam Turbines*

By G. Gerald Stoney

SYNOPSIS—An interesting article dealing with the thermal gains and losses due to vacuum in land and marine turbines.

The degree of vacuum which gives the same velocity ratio at the exhaust end as throughout the whole turbine is the vacuum under which the best results are obtained; consequently, a turbine designed for 29 in. vacuum, barometer 30 in., requires more rows of blades or wheels than one designed for 27 in., the number of rows or wheels of a given diameter in each case being proportionate to the B.t.u. available in the range between the initial and final pressures and temperatures through which the turbine works. There may be considerable latitude in the velocity ratio at the exhaust end without seriously affecting the available economy. Neglecting the effect of the reheat factor, which is small in modern high efficiency turbines, and also neglecting terminal losses, with 175 lb. absolute initial pressure and a superheat of 150 degrees, the gains per inch of vacuum in the B.t.u. available during adiabatic expansion are as shown in Fig. 1 and are:

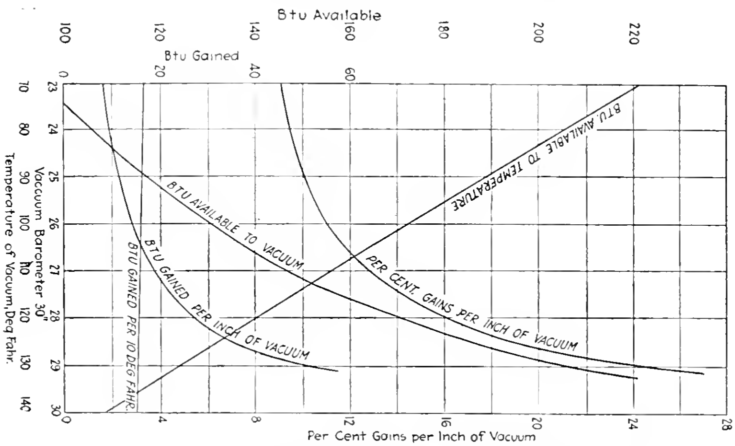


Fig. 1. Distribution of Heat during Adiabatic Expansion; Initial Pressure 175 Lb. Absolute; 150 Deg. F. Superheat

TABLE 1

Between 23 in. and 24 in., 3 per cent. or an increase of 9 B.t.u. on about 300 B.t.u. available at 23 in.

Between 24	in. and 25	in.,	3 per cent.	or	10	B.t.u.
Between 25	in. and 26	in.,	4 per cent.	or	12	B.t.u.
Between 26	in. and 27	in.,	5 per cent.	or	15	B.t.u.
Between 27	in. and 28	in.,	6 per cent.	or	21	B.tu..
Between 28	in. and 28½	in.,	8 per cent.	or	29	B.t.u.
Between 28½	in. and 28¾	in.,	9 per cent.	or	36	B.t.u.
Between 28¾	in. and 29	in.,	11 per cent.	or	42	B.t.u.
Between 29	in. and 29¼	in.,	13 per cent.	or	54	B.t.u.

For saturated steam at 175 lb. absolute, the figures are approximately the same.

In the case of an exhaust turbine working with, say 15 lb. absolute, the gains per inch of vacuum as shown in Fig. 2 are:

TABLE 2

Between 23 in. and 24 in., 9 per cent. or an increase of 10 B.t.u. on about 110 B.t.u. available at 23 in.

Between 24	in. and 25	in.,	10 per cent.	or	11	B.t.u.
Between 25	in. and 26	in.,	11 per cent.	or	13	B.t.u.
Between 26	in. and 27	in.,	12 per cent.	or	17	B.t.u.
Between 27	in. and 28	in.,	14 per cent.	or	22	B.t.u.
Between 28	in. and 28½	in.,	17 per cent.	or	30	B.t.u.
Between 28½	in. and 28¾	in.,	20 per cent.	or	38	B.t.u.
Between 28¾	in. and 29	in.,	23 per cent.	or	45	B.t.u.
Between 29	in. and 29¼	in.,	27 per cent.	or	57	B.t.u.

*From a paper read before the Institution of Mechanical Engineers, England.

For each degree Fahrenheit that the temperature due to the vacuum is reduced, there are approximately 1.5 more B.t.u. available, and this is approximately the case through the whole range considered in tables 1 and 2 and Figs. 1 and 2. These gains due to vacuum are attainable when the turbine can be suitably designed, but, in the case of high-speed, large output land turbines, allowance must be made for increased terminal losses.

For example, in a 3000-kw. land turbine at 3000 r.p.m. with an initial pressure of 175 lb., 150 degrees F. superheat and a vacuum of 29 in., the consumption will be about 12 lb. per kw.-hr., and the steam per hour will be 36,000 lb. or 10 lb. per second. The volume at exhaust, allowing for condensation, will be about 6000 cu.ft. per second. With present materials available, it is not in general customary to go above about 550 ft. per second for the mean velocity of the blades at the exhaust end, giving a mean diameter of 42 in., and as the blade height cannot be more than one-fifth of this, or 8.4 in., the area of the annulus is 7.7 sq.ft. The velocity of the steam leaving the blades through the restricted area will then be 780 ft. per second and involve a loss of 12 B.t.u., assuming that the velocity ratio and angle of the blades are such that the steam leaves them axially, as it should, to give the minimum loss. Even under these conditions there is still a gain of 6½ per cent. between 28 and 29 in. vacuum. For still larger powers these effects become more pronounced, until conditions are eventually reached in this class of turbine having a highly restricted exhaust end when an increase in vacuum causes no gain. It is the aim of designers to increase the limiting vacuum by using higher blade speeds and enabling an exhaust end of larger dimensions to be employed. This is undoubtedly a direction in which increased efficiency in large power high-speed turbines is to be found. The effect of increased blade speed is appreciable, as for a given vacuum the reduction in available gain varies inversely as the fourth power of the blade speed, since as the blade height cannot well be more than one-fifth of the mean diameter of the blades, the area at the exhaust will vary as the square of the diameter, or as the square of the mean blade velocity. Therefore the longitudinal velocity varies inversely as the square of the mean blade velocity, or the B.t.u. lost, inversely as the fourth power. Of course, the reduction can be halved by adopting a turbine with double flow at the exhaust, but this often introduces complications, although many economical land turbines of large power have been designed on these lines. Something can also be done by shaping the exhaust suitably, so as gradually to reduce the velocity of the steam on leaving the blades.

The case of reduced loads will now be considered. With throttle governing, the initial steam-pressure is reduced in accordance with a right-line law similar to the Willans law for the steam consumption, and it may be taken that in this case the initial pressure at no load is approximately atmospheric. If at full load the initial pressure is 175 lb. absolute, at half load it will be about 95 lb., and at quarter load, 63 lb. At half load, with a vacuum of 28 to 28½ in., the percentage gains in consumption per inch of vacuum would be increased by about one per cent., and at quarter load by about two and one-half per cent. above those given in tables 1 and 2, owing to the reduced B.t.u. available by reason of the reduced initial steam-pressure. The amounts of these gains will depend on the velocity ratio throughout the turbine, which has been assumed to be constant at full load.

At reduced loads with throttle governing, the velocity ratio will be approximately the same as at full load throughout the turbine, except near the exhaust end, where it will be greater at reduced loads. This may either slightly increase or diminish the efficiency at the exhaust end, according as the general velocity ratio is high or low, but in general the effect will be small.

With nozzle governing, the gains due to increased vacuum at reduced loads are somewhat less than with throttle governing, and the amount depends on the type of nozzle governing used, but broadly, at full load and at reduced loads the gains in consumption per inch of vacuum are more nearly equal with this type of governing. When a turbine is not bladed so as to give the full velocity ratio up to the exhaust end at full load, it is obvious that the above gains due to vacuum must be modified.

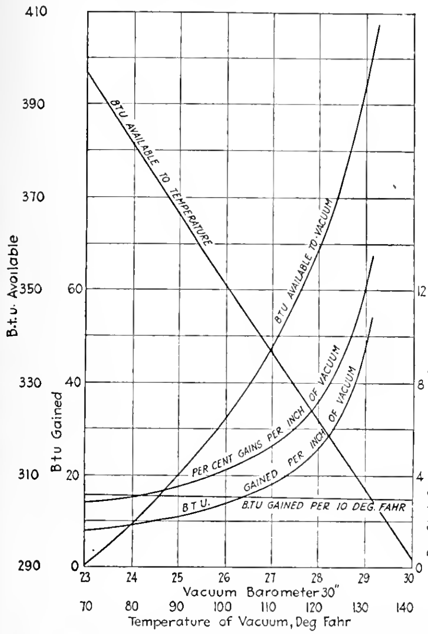


FIG. 2. DISTRIBUTION OF HEAT DURING ADIABATIC EXPANSION; INITIAL PRESSURE 15 LB. ABSOLUTE; SATURATED

Direct-coupled marine turbines especially, from considerations of weight and space, are often bladed to give uniform velocity ratio at full speed with about 26 in. vacuum, and from various causes many land turbines have been similarly bladed. In turbines so bladed and with ordinary steam pressures, it has been found by experience that the gain per inch of vacuum at full load is as follows:

Between 26 in. and 27 in., 4 per cent. or 12 B.t.u.
Between 27 in. and 28 in., 5 per cent. or 17 B.t.u.
Between 28 in. and 28½ in., 6 per cent. or 22 B.t.u.
Between 28½ in. and 29 in., 7 per cent. or 27 B.t.u.

In the turbines so bladed and at constant speed, as in land work, the velocity ratio at the exhaust end would automatically become at half load uniform with the rest of the turbine at about 28 in., and for quarter load, at about 28¾ in., so that in general it may be said that the theoretical gains as given will be completely obtained at reduced loads, but for strict accuracy, each case should be considered on its merits. It may be noted here that, although there is a decrease in efficiency at the exhaust end by having a cramped exhaust and low velocity ratio, there is but little loss when the exhaust end is large and has an unnecessarily high velocity ratio.

Marine turbines running at reduced speeds when the load is reduced may now be considered. Geared turbines can be and should be bladed for high vacuum, and the blading should be for nearly the highest vacuum obtainable in the waters in which the ship trades, as there is but little loss by running a turbine bladed for high vacuum at a lower one. For example, it should be bladed for 28½ to 29 in., the vacuum obtainable in home waters and the like, and not for 27½ to 28 in., which will be the vacuum obtainable in the tropics with a good condensing plant. In such turbines the full theoretical gain due to vacuum will be attained at full speed. At half speed and one-eighth power, if the consumption at full load is assumed to be 12 lb. per shaft horsepower, and at half speed 16 lb., the steam at half speed will be one-sixth that at full speed, and the velocity ratio three times that at full speed for the same vacuum, so that the exhaust end is amply large enough for the highest vacuum which can be attained, and therefore the gain due to increased vacuum will be somewhat more than that at full speed.

In most cases, blading a geared turbine for high vacuum as compared with low vacuum adds little to the weight, and generally only necessitates the exhaust end being made somewhat larger. It is important that the exhaust between the turbine blades and the condenser should be free and unrestricted, so that the loss of vacuum between the last row of blades and the steam space in the condenser should be a minimum. This applies to all classes of turbines.

It is equally important that the loss of vacuum between the steam space in the condenser and the air-pump suction should also be a minimum. In other words, given a condenser and an air pump of the highest efficiency, the difference in vacuum between the air-pump suction and exhaust end of the turbine should be reduced to an absolute minimum. The importance of this requirement should be carefully noted when analyzing data obtained from any particular turbine installation, whether land or marine, as otherwise erroneous conclusions may be formed. For example, if any of the many factors in design which influence the efficiency of any given installation as a whole are not provided for, it is futile to carry a vacuum higher than such provisions warrant: the consequent sacrifice in economy is measured in such cases by what is obtained and what is obtainable Sometimes a definite velocity is fixed on for the velocity of the steam in the exhaust, but this has the difficulty that it depends on the vacuum for which the condenser is designed. A better way is to make the area of the exhaust have a definite ratio to the area of the annulus of the last row of blades, and in direct-coupled marine turbines this ratio is generally 1.5 to 1.7, but in geared turbines it can be increased to about 2.

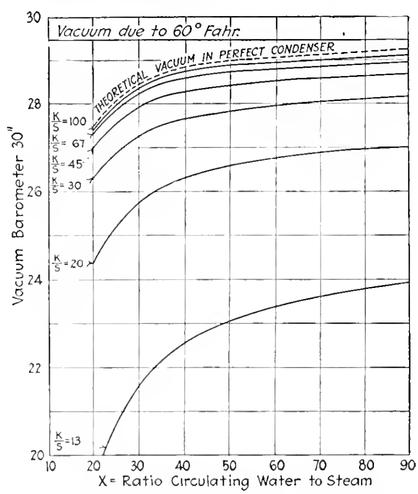


FIG. 3. VACUUMS WITH DIFFERENT AMOUNTS OF COOLING WATER

This means that, if the reduction of velocity can be made to take place gradually as in a diverging orifice, most of the terminal loss at the blades will be recovered, and much can be done in this direction by careful attention to having gradually diverging stream lines of steam from the blades to the condenser. A rule sometimes used on land is to have 18 to 20 lb. of steam per hour per square inch of exhaust area, and in many cases this works well. More careful attention is required in the future as to the shape of the exhaust, for at present many exhausts are so shaped as to cause considerable and unnecessary loss of vacuum.

The case of a direct-coupled marine turbine, only bladed for 26 in. at full speed, is rather different. Here, at full speed, the effect of vacuum will be as given on page 312, but the cases of half speed and one-eighth power have to be specially considered, more particularly on account of such devices as cruising turbines, etc. If we assume the steam per shaft horsepower with Parsons turbines to be 13 lb. at full speed and 21 lb. at half speed, and that the shaft horsepower at half speeds is one-eighth that at full speed, the steam per hour will be one-fifth that at full speed. Assuming that throughout the main turbines generally the velocity ratio is 0.5 at full speed, then at half speed the velocity ratio throughout the main turbines will be 0.25, except at the exhaust end, where it will be 1.25. This means that the full effect of vacuum will be obtained up to over 29 in., and on account of the low velocity ratio, the effect, provided the condensing plant will respond, will considerably exceed the theoretical at lower vacuums.

Up to the present the turbine alone has been considered, but in a complete installation, whether land or marine, there are many other factors to be taken account of. As increase in vacuum is associated with a correspondingly lower temperature of condensate, it follows that if the vacuum is raised

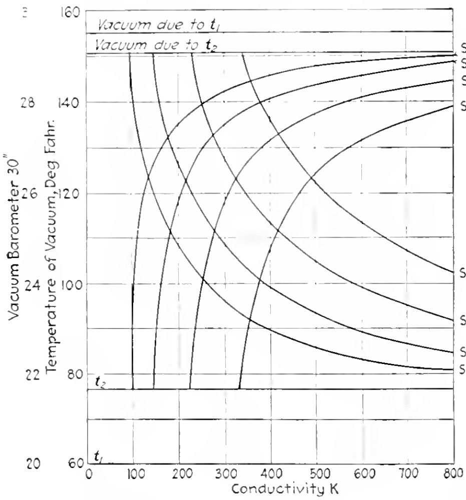


FIG. 4. VACUUMS AND TEMPERATURES WITH VARYING CONDUCTIVITY: CIRCULATING WATER (60 DEG. F.) 60 TIMES AMOUNT OF STEAM CONDENSED

and the condensate is delivered to the boiler at the same temperature at which it leaves the condenser, either the quantity of steam generated in the boiler per unit of coal is decreased or the quantity of coal per unit of steam generated is increased. If the difference between the temperature due to the vacuum and that of the condensate is taken as constant, a reduction of 10 degrees in the temperature of the feed-water delivered to the boiler is equivalent to an increase of about one per cent. in coal consumption per unit of steam generated, or

Between 26 in. and 27 in. = 1 per cent.
Between 27 in. and 28 in. = 1½ per cent.
Between 28 in. and 29 in. = 2 per cent.

Such a condition never arises in practice on land or at sea, as the condensate is invariably heated either by the waste gases from the boiler or by the exhaust steam from the auxiliary engines, or by both. Land installations usually include an economizer in the boiler uptake, and the practical requirement in such a case is that, in order to prevent sweating on the tubes, the feed water should be delivered to the economizer at a temperature of about 120 degrees F. But even at the highest vacuum there is usually sufficient exhaust steam from the auxiliaries to raise the condensate to this temperature, so that such a system represents the highest economy attainable with any given plant.

Marine installations present a different problem by reason of the large quantity of exhaust steam available from the auxiliary engines, and it may be noted that the heat in exhaust steam is used to the greatest advantage possible when it is redelivered to the boiler with the feed water. It follows that in order to attain maximum economy on shipboard, all the exhaust from auxiliary engines should be condensed by the feed water. A perfect installation from this point of view would be one in which the turbine works under the highest attainable vacuum with efficiency, and in which the exhaust steam is maintained at such pressure as will enable its heat to be wholly transferred to the feed water. In fact, the economic pressure for the auxiliaries to exhaust at is that in which the whole of their exhaust can be condensed by the feed. Obviously there should be no surplus exhaust, and if there is, it should never be discharged into the main condenser, because of the highly prejudicial effect of oil on the heat-transferring efficiency of the condenser tubes and on the vacuum. The direction in which progress is to be made on marine turbine installations would, therefore, appear to be, (a) high vacuum turbines; (b) high efficiency condensing plant; (c) economical auxiliaries; (d) efficient exhaust-steam feed-heaters.

In some cases where there is a surplus of auxiliary steam it is turned into the low-pressure turbine, and here there is an apparent partial recovery of the loss, but this arrangement has the defect of fouling both the turbines and the condenser with oil and reducing their efficiency, so that the power of the turbine may easily be reduced to a far greater extent than it can be increased by the use of such surplus steam. If, however, the steam is used in this way, it should be carefully filtered.

In order to consider further the effect of vacuum on an installation, it is necessary to consider the question of the condensers and the power necessary to work them. In a surface condenser there are three losses to be considered: (a) the temperature rise in the circulating water; (b) the resistance of the tube to heat transmission from the steam to the water; (c) air insulation of the condensing tubes.

These may be summed up in the apparent conductivity K of the condenser—that is, the B.t.u. transmitted per square foot per hour per degree Fahrenheit difference of temperature between the steam and the water.

Let

- t_1 be the temperature in degrees Fahrenheit of the inlet water to condenser.
- t_2 be the temperature in degrees Fahrenheit of the water leaving the condenser.
- T be the temperature in degrees Fahrenheit due to the vacuum.
- X the ratio of circulating water to steam condensed.
- S steam condensed per square foot of condenser surface per hour.

(For convenience this is reckoned on the outside of the tubes.)

Then

$$K = 2.3\, S\, X \log \frac{T - t_1}{T - t_2}$$

As it takes in ordinary practice about 1000 B.t.u. to condense each pound of steam we may write

$$1000 = X\,(t_2 - t_1)$$

and writing

$$T - t_2 = \delta$$

the equation becomes

$$K = 2.3\, S\, X \log \frac{\delta + \frac{1000}{X}}{\delta}$$

As the maximum vacuum a condenser can produce is that due to the temperature of the exit water, the object of the designer is to have δ as small as possible. With a condenser in average conditions of cleanliness and efficient air withdrawal, the value of the conductivity K is obviously much higher than with inferior air extraction or a dirty condenser. The conductivity is also influenced by the load. For example, in a heavily loaded condenser, under the best conditions, a value of K of 1500 or even higher has been reached, while in condensers under low load it may be no higher than 300, so that this method of comparison requires to be used with some discretion.

Fig. 3 shows the vacuums obtainable with various values of K, S and X, and Figs. 4 and 5 the effect of conductivity at various rates of condensation for X = 60 and X = 30. All these are for an inlet temperature of 60 deg. F. and similar curves can be plotted for any other temperature, but as they are all similar in character, those for 60 deg. F. are alone given. It will be observed from Figs. 4 and 5 that the effect of reduced conductivity, such as is caused by air, is much more at high rates of condensation than at low, showing that the effect of a faulty air pump or dirty condenser is much more when the rate of condensation is high. It will also be seen that, approximately, the loss of vacuum below that theoretically obtainable depends only on the rate of condensation and on the amount of air insulation, and not on the quantity of circulating water—that is, that δ is approximately independent of X, always assuming a condenser free from oil on the outside of the tubes and scale on the inside. From the curves it follows that there is not much use in having more circulation water than about sixty to eighty times the steam condensed at full load in home waters and the tropics respectively.

Figs. 4 and 5 also show the importance of having ample surface, and confirm what has often been found, that money put into a condenser of ample size is money well spent. Ample surface also gives a good margin to allow of the condenser getting dirty or for overloads. With a high rate of condensation, especially if the condenser is dirty, when an overload is required the vacuum will drop so much that not only is there often difficulty in getting the overload out of the turbine, but the boilers are still further overtaxed due to increased steam consumption causing the steam pressure to drop just at the time it is most important to have full pressure. It is usual in modern power stations to have a vacuum of about 29.1 in., barometer 30 in., with 50 deg. F. cooling water and circulating water 65 times the steam condensed, and 28 in. with 80 deg., 70 times, and it seems as if these conditions cannot be much improved upon, as, if the circulating water were increased in this case from 65 to 100 times the steam, the improvement in vacuum would only be about ⅛ in., and the pumps and circulating pipes would have to be increased 50 per cent. With 65 times as much and a moderate rate of condensation, such as 6 to 8 lb. per square foot at normal load, there is an ample margin for overload, an overload of 50 per cent. only reducing the vacuum by about half an inch.

In cases where there is not a supply of natural cooling water or only a restricted supply, or where cooling towers are used, the question of the best vacuum must be most carefully considered, and so many factors come into the case that each problem must be considered on its merits and alternative schemes worked out to find which is best. Such cases it is not proposed to deal with in this paper.

In the mercantile marine, the only question that has to be considered is the case of full speed at sea, and everything has to be arranged for the highest economy at that speed. In a recent geared turbine meat-carrying ship, the turbine is bladed for about 28½ to 28¾ in. vacuum, and the condensers have a surface of 8 lb. per square foot or 1½ sq.ft. per shaft horsepower, or equivalent to, say, 1.35 per i.h.p., and circulating water equal to 75 times the steam condensed, so as to provide for tropical waters. The vacuum is 29.1 in. with 50 deg. F. sea temperature, 28.8 in. with 60 deg. F., and 28 in. with 80 deg. F.

The weight of the Scotch boilers is 62 per cent., of the main turbines 12 per cent., of the condensers 3 per cent., of the circulating and air pumps with their pipes 5 per cent., and of other auxiliaries, pipes, etc., 18 per cent. of the total weight in engine and boiler rooms.

If the surface of the condensers were halved, giving 16 lb. per square foot, keeping the same circulating water, there would be a loss of vacuum of about one-half inch, and a saving on the total weight by the smaller condensers of 1½ per cent. This would increase the steam consumption by, say, 5 per cent., and therefore the weight of the boilers, by 5 per cent., and the total weight by 1½ per cent., not to speak of the 5 per cent. extra coal that would have to be carried. A reduction in the circulating water would also tend the same way. It is much more economical to save at the low temperature or condenser end of the system than at the high temperature or boiler end, and therefore to have as high an efficiency in the condensing plant as possible and turbines made to suit. The increase of weight in the condensers and turbines is much more than counterbalanced by the saving of weight in the boilers and coal to be carried. High efficiency in the condensing plant means not only sufficient surface and sufficient circulating water, but also most efficient air withdrawal, as, for example, by a steam jet.

The case of warships has also to be considered. In the case of a battleship with direct-coupled turbines, the weight of the water-tube boilers is 35 per cent., turbines 25 per cent., condensers 3 per cent., circulating and air pumps, etc., 4 per cent., and other auxiliaries, etc., 33 per cent. of the total engine and boiler room weights. The condensers condense at full power 18 lb. per square foot, and the circulating water is 65 times the steam. This gives, with 60 deg. F. sea temperature, a vacuum of 28¼ in. Direct-coupled warship turbines are bladed for about 26 in. for reasons given before, but with geared turbines bladed for higher vacuums, it is evident that it would pay to reduce the boilers and increase the condensers. At reduced speeds the condensers are lightly loaded, and here, as explained before, the highest vacuums can be taken advantage of by the turbines. With the lightly loaded condensers, the loss of temperature and vacuum due to the conductivity between the water and the steam through the tubes becomes small, and the important point is efficient air withdrawal.

At half speed or one-eighth power the condensers are only loaded to about 4 lb. per square foot, and as the vacuum is generally only about 28½ in., this means a conductivity of about 150 as against 600 to 800 B.t.u. at full load. But if greater care were taken to install air-withdrawing apparatus of the highest efficiency and ample capacity, such, for example, as is obtainable with a steam-jet combination, this vacuum could be raised to 28¾ or 29 in. with sea water at 60 deg. F., provided the condenser was of suitable design, thereby effecting a gain of at least 3 per cent. on the coal consumption, an amount which would far outweigh the comparatively slight additional cost and weight of the apparatus. This gain is independent of the drop of temperature of the condensate, as at low powers there is always more exhaust steam available than can be condensed by the feed water. Other types of warships can be similarly considered, but the case of the destroyer is especially difficult, as it is essentially a compromise, and here it has been considered economical to load up the condensers at full speed to about 27 lb. per square foot and reduce the circulating water to about fifty times.

With the advent of geared turbines the case becomes different, since they can be bladed for high vacua with little increase in the weights and sizes of the turbines, and it is clear that the greatest benefits from the highest vacua will be found. It is to be expected that in such cases there will be a large increase in the surface of the condensers and improvement in air withdrawal, with a consequent reduction in the boilers and fuel carried.

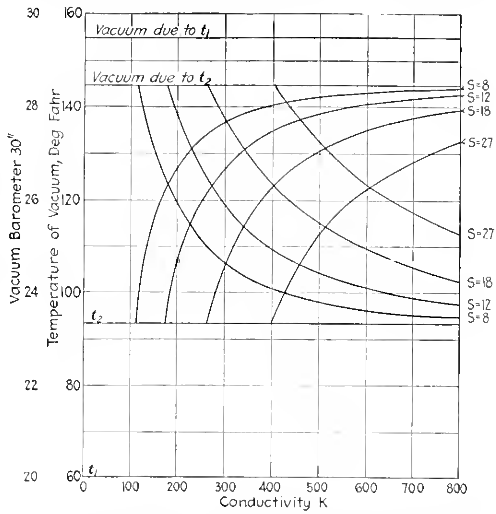


FIG. 5. VACUUMS AND TEMPERATURES WITH VARYING CONDUCTIVITY; CIRCULATING WATER (60 DEG. F.) 30 TIMES AMOUNT STEAM CONDENSED

The aims of an efficient condenser are to have the maximum of heat transfer from the steam to the circulating water—that is, a minimum difference between the temperature due to the vacuum and the temperature of the circulating water leaving the condenser, and also to deliver the condensate to the hotwell as near the temperature due to the vacuum as possible. And here it is important to consider the steam consumption of the auxiliaries and the air-withdrawal arrangements which comprise air pumps in some form, together with the withdrawal of the condensate from the condenser. It is not proposed to enter into the different types of air pumps, but as the driving power of these pumps is at most only about one per cent. of the power of the turbine at full load, and in general much less, the importance of the steam used per unit of power required for driving an air pump is negligible compared with its vacuum-producing qualities. The steam required by the circulating pumps depends on the steam consumption W in lb. per water horsepower-hour, of the engine driving the circulating pumps, the ratio X of the circulating water to the steam condensed, and the total head h in feet on the pumps. We have then

$$\text{percentage of steam used by pump} = \frac{WXh}{20,000}$$

For example, if we take W = 60, X = 60, and h = 20 feet, we have percentage used = 3.6.

For X = 30, the percentage is 1.8.

The difference in the hotwell temperature, between condensers using these quantities of circulating water, is about 17 deg. F., so that without allowing for condensation it may be said that in this case the temperature of the feed, after it has condensed the steam from the circulating pump, is largely independent of the quantity of circulating water, and this has to be considered in making up the final balance sheet, which alone enables the most difficult problem of the best vacuum for any particular installation to be considered.

Midwinter Convention of A. I. E. E.

The third midwinter convention of the American Institute of Electrical Engineers was held at the Engineering Societies Building, New York City, on Feb. 17 to 19. In his opening address, President Paul M. Lincoln referred to the great service of an engineering society in promoting exchange of ideas, the idea usually being worthless unless passed along to receive the benefit of other minds.

The application of electric motors was the topic of the first session, D. B. Rushmore opening it with a paper on "The Characteristics of Electric Motors." This paper, in the nature of an outline, was followed by carefully prepared discussions on different types of motors, each speaker selecting a particular type.

On Wednesday afternoon five papers were presented: "Effect of Moisture in the Earth on Temperature of Underground Cables," by S. E. Imlay; "Oil Circuit-Breakers," by K. C. Randall; "Comparison of Calculated and Measured Corona Loss Curves," by F. W. Peek, Jr.; and "A 100,000-Volt Portable Substation," by C. I. Burkholder and Nicholas Stahl.

Three papers comprised the Thursday morning program: "Distortion of Alternating-Current Wave Form Caused by Cyclic Variation in Resistance," by Frederick Bedell and E. C. Mayer; "Dimmers for Tungsten Lamps," by A. E. Waller; and "Searchlights," by C. S. McDowell.

The Friday morning session was devoted to "Electrical Precipitation," three papers being presented, namely: "Theory of the Removal of Suspended Matter from Fluids," by W. W. Strong; "Theoretical and Experimental Considerations of Electrical Precipitation," by A. F. Nesbit; and "Practical Applications of Electrical Precipitation," by Linn Bradley. The last technical paper was on "Electrical Porcelain," by E. E. F. Creighton.

STATUS OF THE ENGINEER

The most interesting feature of the convention program was the discussion on Wednesday evening of the "Status of the Engineer." The list of speakers showed that care had been exercised to have the subject dealt with from several angles. A. C. Humphreys, president of Stevens Institute, and Prof. G. A. Swain, of Harvard, represented those responsible for the training of engineers; E. W. Rice, Jr., president of the General Electric Co., and E. M. Herr, president of the Westinghouse Electric & Manufacturing Co., represented the largest employers of engineers, and L. B. Stillwell, H. G. Stott and J. J. Carty represented successful engineers now actively engaged in the profession.

Mr. Stillwell in opening the discussion predicted that if the engineer would take a more active part in public affairs, proper recognition would follow. To this end, however, more liberal and less technical education is needed in the colleges. He charged the national engineering societies with having failed to raise the prestige of engineers, pointing out by way of comparison what the Bar Association has done for the legal profession. In this connection he suggested that the engineering societies jointly formulate a code of ethics, which should be enforced strictly, even to the point of expulsion from membership for any violations of the rules. Furthermore, the societies should adopt a policy with regard to license legislation and also advise on public questions such as water-power development, etc.

Mr. Rice in taking up the discussion reviewed some of the engineering achievements and their effects upon modern civilization; yet engineers have practically no voice in running the Government. In the present Congress there is only one engineer out of a total of 435 members in the House and none in the Senate, about 70 per cent. being lawyers. In view of the number of public problems directly or indirectly related to engineering, which are up for consideration it would seem advisable that the representation include some who have had engineering training. "This training," said Mr. Rice, "makes a man search for facts and represents a blending of conservatism and radicalism."

E. M. Herr, speaking from the standpoint of the manufacturer, believed that mathematical training and analysis tend to unfit a man to deal with the human element, and attributed to this fact the failure of many engineers in successfully handling men. He advised the application of the "Golden Rule" as the best solution to this phase of the problem.

Speaking from his experience as an educator, Doctor Humphreys was of the opinion that boys now come to college poorly prepared, because much of their time has been taken up in the preparatory schools with irrelevant studies. He believed that the engineer should receive a more liberal education, but did not advocate a six-year course, adding: "The sooner a man gets out of college after learning the fundamentals, the sooner will he become a specialist." With regard to present regulative tendencies of the government through commissions, Doctor Humphreys seemed to think that it was being carried too far, and often took the form of control rather than regulation. He especially lamented the apparent disposition in some circles to regard business as dishonest, and expressed the belief that with engineers occupying a prominent part in the Government and on commissions, this country would be brought back to a sane regulation of its affairs.

Professor Swain endeavored to show why engineers as a class are not recognized to the same extent as men in many other professions. "Leadership," he said, "depends upon personal qualities, some inherent and others received by training, and it is doubtful whether engineers think straighter than lawyers or business men, or have greater breadth of view. In fact, the engineer is apt to confine himself too closely to technical subjects to the exclusion of outside affairs." As a remedy for this condition, he suggested a broader curriculum in the technical schools, with less details, which can be learned later, and a better training in English and in such liberal subjects as will promote personal qualities. The speaker believed the remuneration in engineering to be fair and comparable with the average in other professions, although admitting that large fees were the exception rather than the rule in engineering. The ability of doctors and lawyers to command large fees was probably due to the character of their work appealing to the emotions, or in the case of the architect to the vanity of the client; whereas in the case of the engineer his work is a cold business proposition and its value is measured accordingly.

Mr. Stott seemed to think the present status of engineers fairly satisfactory, although he believed that engineers in the government service are often deprived of proper credit by their superiors, who often have no technical training whatever. He believed engineers should specialize and, in doing so, should follow their own inclinations.

Mr. Carty spoke of the engineer as concerned with problems of organization, but warned against "scientific management" masquerading as engineering.

The entertainment included a trip to the new power house of the United Electric Light & Power Co. on Thursday afternoon and a dinner dance at the Hotel Astor that evening.

Boiler Inspectors' Banquet

Probably the most successful and most enjoyable so far was the fifth annual dinner of the New York Section of the American Institute of Steam Boiler Inspectors, held at Rectors in New York, Feb. 20. The attendance was large, 110, made up of people interested directly or indirectly in the inspection of boilers. In the role of toastmaster Michael Fogarty distinguished himself as usual. The speakers in addition to the incoming, retiring and past officers of the Institute were: Dr. D. S. Jacobus, of the Babcock & Wilcox Co., who rehearsed something of the history of the American Society of Mechanical Engineers' Proposed Boiler Code, with which he, as a member of the advisory committee, was very familiar; Fred R. Low, editor of "Power," and Herman Van Ormer and John H. Gleason, both of the Boston office of the Hartford Steam Boiler Inspection & Insurance Co., and Inspector Lanigan of the New York boiler squad.

Shrinkage During Solidification—A few exceptions to those substances which undergo the usual shrinkage during the process of solification are pointed out by the "Mechanical World." These exceptions include cast iron, antimony and bismuth. When melted cast iron is poured into a mold it expands in solidifying and presses into every part of the mold. The pattern in the casting is, therefore, as clearly traced as it was in the mold. After it has changed from a liquid to a solid, however, the order is reversed, and in cooling down from the first stage of solidification to normal temperature a shrinkage of about ⅛ in. to the foot takes place.

A clear-cut cast cannot be obtained from lead, which is one of the reasons why antimony is made a constituent of type metal. Gold coins have to be stamped; they cannot be cast so as to produce a clear-cut design, for the same reason.

Opening of the Exposition

At noon, Pacific Coast time (3 p.m. Eastern time), Saturday, Feb. 20, President Wilson pressed a button in Washington giving an electric signal for the opening of the Panama-Pacific International Exposition in San Francisco. In last week's issue a number of the features of the Fair were given as most likely to interest "Power" readers, and more is yet to be printed of certain of the exhibits and the lessons to be drawn from them with respect to past, present and future.

As the day of opening dawned, the city which had been looking forward to it so long seemed fairly to break out with its pent-up enthusiasm. For an hour from 6:30 o'clock, all means of noise-making seemed to be in commission, from steam whistles, automobile horns, car gongs and church bells down to rattles, tin horns and the usual facilities available to the individual. A large crowd had gathered on the grounds hours before the opening, and before the end of the day the attendance had broken all records of like kind, exceeding 300,000, in spite of the clouds and showers.

The dedicatory ceremonies were short and simple. The citizens, headed by Governor Hiram W. Johnson and Mayor Rolph, representing the state and city, were welcomed to the grounds by the officers and directors of the Exposition and officers of the Federal Government. Addresses were delivered by President C. C. Moore of the exposition, Dr. Frederick J. V. Skiff, director-in-chief; Governor Johnson, Secretary of the Interior Frank K. Lane representing President Wilson, and a few others. Invocations and benedictions were pronounced by clergymen representing the Roman Catholic, Protestant and Jewish faiths. President Wilson forwarded a message of congratulation to the directors, which was read to the crowd.

At the Washington end the ceremony was staged in the East Room of the White House, where places were reserved for members of the Cabinet and the California delegation in Congress. Assistant Secretary of the Navy Roosevelt represented the Government Exposition Board. At the President's touch, two signals were sent, one by telegraph to San Francisco and one by wireless to Tuckerton, N. J., and relayed thence to San Francisco.

With the receipt of the signal the Fountain of Energy was started, flags of all the nations were raised on the various poles and pinnacles, signal bombs were exploded from towers, an aëroplane circled the Tower of Jewels, scattering doves of peace, and the doors of the Palace of Machinery swung open, revealing the exhibits within in motion.

PERSONALS

James Smieton, Jr., who has been acting in that capacity for the past year, has been appointed secretary-treasurer of the Society for Electrical Development.

N. H. Brown, until recently Chicago representative of the Bury Compressor Co., has been made sales engineer of the Erie Pump & Equipment Co., Erie, Penn., successor to the Northern Equipment Co. and the Erie Pump & Engine Works.

John S. Huey, formerly with the Allis-Chalmers Manufacturing Co., and more recently with Woodward, Wight & Co., has been appointed by the Kerr Turbine Co., Wellsville, N. Y., as its district sales agent for Louisiana and southern Mississippi. His office is in Room 418, Hibernia Bank Bldg., New Orleans, La.

Matthew T. Slattery, an Ohio state boiler inspector in general charge of the district which includes Cleveland, has been appointed commissioner of the Cleveland smoke prevention division to succeed E. P. Roberts, whose resignation was recently noted.

William M. Davis, an occasional contributor to "Power," has accepted a position as efficiency engineer for the Texas Co. He will have a force of a dozen or more in service, who under his direction will be trained to make surveys and inspections of customers' plants and prepare reports showing how to obtain the best service with the lubricants in use.

John W. Exler has been elected president of the James Lappan Manufacturing Co., of Pittsburgh, Penn. Mr. Exler has been employed as a boiler maker and iron worker for over 40 years. In the '80s he was engaged as foreman with the Niles (Ohio) Boiler Co., and later with Reeves Bros. Co., at Alliance, Ohio. He has also filled some important positions with large Pittsburgh manufacturing concerns.

A. S. Baldwin has resigned as manager of the Best Manufacturing Co., to take effect not later than Apr. 1. This company has recently been absorbed by the Kennedy-Stroh Corporation, which has its complete organization. Mr. Baldwin was for two years superintendent of the American & British Manufacturing Co., Bridgeport, Conn.; four and one-half years general superintendent of the Driggs-Seabury Ordnance Corporation, Sharon, Penn., and for three years general manager of the Alberger Pump & Condenser Co., Newburgh, N. Y. For the present his address is General Delivery, Oakmont, Penn.

Erasmus Darwin Leavitt, of Cambridge, Mass., has been elected an honorary member of the American Society of Mechanical Engineers, of which he was the second president. Mr. Leavitt was assistant engineer in the United States Navy from 1861 to 1867, consulting engineer for the Calumet & Hecla Mining Co. from 1874 to 1904, and has acted as consulting engineer in many large capacities. He is a member of all of the professional engineering societies, and was awarded the degree of Doctor of Engineering by Stevens Institute of Technology in 1884.

ENGINEERING AFFAIRS

Technical Associations' Secretaries—Technical societies and associations have become so numerous and important that a society of Technical Associations' Secretaries has been organized, and held its first annual meeting in the rooms of the American Society of Mechanical Engineers, Engineering Societies Building, 29 West 39th St., New York, on Saturday, Feb. 27.

Transactions of the International Engineering Congress (to be held Sept. 20-25, at San Francisco, Calif.)—Volume I will comprise a unique series of papers on the engineering of the Panama Canal. The various topics and subdivisions of the work have been arranged by Col. G. W. Goethals, chief engineer of the canal, and now governor of the Canal Zone. Col. Goethals has also selected the author for the treatment of each paper, and he will himself contribute the introductory chapter. The various authors are, in general, the officers who were in direct charge of the actual work of construction, and the collection of papers thus becomes a first-hand account of the engineering of the canal, written by the men who were in immediate and responsible charge of the undertaking. There will be 24 papers in all, profusely illustrated, 22 of which deal with actual constructive and engineering problems connected with the work, one with the preliminary work in municipal engineering in the Canal Zone, and one with the commercial and trade aspects of the canal. This volume can be obtained only through enrollment in the congress. The transactions of the congress as a whole will include from seven to nine other volumes, covering all important phases of engineering work. Membership in the congress, with the privilege of purchasing any or all of the volumes of the proceedings, is open to all interested in engineering work. Full particulars can be had upon application to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

NEW PUBLICATIONS

HOW TO RUN AND INSTALL A GASOLINE ENGINE. By C. Von Culin. Published by Norman W. Henley Publishing Co., 132 Nassau St., New York City, 1915. Revised Edition. Size, 3¼x6 in.; 96 pages, illustrated. Price, 25c.

This little book is printed as a pocket instructor for the beginner or the busy man who uses a marine engine for pleasure and who does not have the time or the inclination for a complete technical perusal of the subject. The method of treating the various topics by the author is such that a man who has no technical knowledge of a gasoline engine may obtain enough information to enable him to operate one successfully, either of the two- or four-stroke-cycle type. Many pointers are given regarding the causes of trouble in gasoline engines, and the remedies. If the reader absorbs all the information contained in the book he should be able to operate his gasoline engine without any particular trouble. The book is well illustrated and contains a remarkable amount of information for such a small volume.

HAND FIRING SOFT COAL UNDER POWER-PLANT BOILERS is the title of Technical Paper 80, by Henry Kreisinger, issued by the U. S. Bureau of Mines, as an aid to firemen throughout the United States. Copies may be obtained without cost by addressing the Director of the Bureau of Mines, Washington, D. C.

The paper, which contains descriptions of methods of firing soft coal under power-plant boilers and of handling fires so as to have the least smoke and to get the most heat from the fuel, seeks to meet the needs of the men, many without technical education, who are employed in small plants. For this reason the language used is plain and simple, and technical terms have been avoided as far as possible.

Under "General Directions on Firing Soft Coal," the following statements are made:

When burning bituminous coal under power-plant boilers the best results are obtained if the fires are kept level and rather thin. The best thickness of the fires is four to ten inches, depending on the character of the coal and the strength of draft. The coal should be fired in small quantities and at short intervals. The fuel bed should be kept level and in good condition by spreading the fresh coal only over the thin places where the coal tends to burn away and leave the grate bare.

Leveling or disturbing the fuel bed in any way should be avoided as much as possible; it means more work for the fireman and is apt to cause the formation of troublesome clinker. Furthermore, while the fireman is leveling the fires a large excess of air enters the furnace, and this excess of air impairs the efficiency.

The ashpit door should be kept open. A large accumulation of refuse in the ashpit should be avoided, as it may cause an uneven distribution of air under the grate. Whenever a coal shows a tendency to clinker, water should be kept in the ashpit. All regulation of draft should be done with the damper and not with the ashpit doors.

In firing, the fireman should place the coal on the thin spots of the fuel bed. Thin and thick spots will occur even with the most careful firing, because the coal never burns at a uniform rate over the entire grate area. In places where the air flows freely through the fuel bed the coal burns faster than in places where the flow of air is less. The cause of this variation in the flow of air through the different parts of the fuel bed may be differences in the size of the coal, accumulations of clinker, or the fusing of the coal to a hard crust. Where the coal burns rapidly, the thin places form.

Before throwing the fresh coal into the furnace the fireman should take a quick look at the fuel bed and note the thin spots. In a well-kept fire these spots can be usually recognized by the bright hot flame. The thick places have either a sluggish smoky flame or none at all. In order to place the coal over the thin places the fireman should take a rather small quantity of coal on his scoop, for it is much easier to place the coal where it is needed with small shovelfuls than with large ones.

The coal should be placed on the thin places in rather thin layers. If the fireman attempts to fill up the deep hollows in the fuel bed at one firing, the freshly fired coal may fuse into a hard crust, thus choking the flow of air, causing the fuel to burn slowly and starting new high places. If the high places in the fuel bed are missed on one or two firings the hard crust at the surface will gradually burn through or crack, thus allowing more air to flow through, and the place will get back to its normal condition. Of course, if the high place in the fuel bed is caused by clinker the flow of air will not be free until the clinker is removed with the fire tool. Whatever may be the cause of the high places in the fuel bed, the fireman should remember that they are places where the coal does not burn. There is no use in putting coal on such a place.

If the firings are too far apart the coal in the thin spots may burn out entirely, allowing a large excess of air to enter the furnace in streams. If those streams of air are not properly mixed with the gases from the coal, only a small percentage of the air is used for combustion, and most of it passes out of the furnace, depriving the boiler of considerable heat. If, for instance, air enters the furnace at atmospheric temperature, say 75 deg. F., and leaves the boiler at about 575 deg. F., it carries away the heat that was absorbed in raising its temperature 500 deg. F. This heat is lost to the boiler. Another loss of heat occurs when holes form in the fuel bed, because pieces of unburned coal fall through the grate when the fireman attempts to cover the holes with fresh coal. Therefore, in order to avoid the formation of holes, firings should be made at short intervals, particularly if, for any reason, the fuel bed must be kept thin.

NEW PUBLICATIONS OF THE BUREAU OF MINES

Fourth Annual Report of the director of the Bureau of Mines to the Secretary of the Interior, for the fiscal year ended June 30, 1914; 101 pages.

Bulletin 84, Metallurgical Smoke. By Charles H. Fulton; 92 pages; 6 plates; 14 figures.

Bulletin 85, Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1911 to 1913. By A. C. Fieldner, H. I. Smith, A. H. Fay and Samuel Sanford; 44 pages; 2 figures.

Technical Paper 80, Hand-firing Soft Coal under Power-Plant Boilers. By Henry Kreisinger; 83 pages; 32 figures.

Miners' Circular 21, What a Miner Can Do to Prevent Explosions of Gas and of Coal Dust. By G. S. Rice; 24 pages.

Publications should be ordered by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

A Simple Test for Animal and Vegetable Contents in oil is to shake up with the sample in a test tube about one-fifth or one-quarter of its own volume of a saturated solution of borax in water. The presence of animal or vegetable matter is indicated by an opaque white line of saponification, which forms between the water and the oil after they are allowed to separate. Paraffin in oil may be detected by heating a sample up to 450 deg. The presence of paraffin is indicated by a material darkening in the color of the oil.

TRADE CATALOGS

Chain Belt Co., Milwaukee, Wis. General Catalog No. 56. Elevating, conveying and concrete machinery. Illustrated, 304 pp., 6x9 in.

Jeffrey Mfg. Co., Columbus, O. Bulletin No. 147. Swing hammer pulverizers for coal, etc. Illustrated, 48 pp. Bulletin No. 167. Belt conveyors. Illustrated, 24 pp.

Wm. B. Scaife & Sons Co., 221 First Ave., Pittsburgh, Penn. Pamphlet. "Pure Clear Ice." Illustrated, 12 pp., 5x8 in. Pamphlet. Central Power Station Economy. Illustrated, 8 pp., 4x9 in.

CATALOGS WANTED

The Compressed Gas Manufacturers' Association, Incorporated, requests manufacturers of valves, cylinders, recording gages, filling and weighing stands and of material and appliances which enter into the manufacture, transportation and sale of compressed gases to send catalogs, price lists and full descriptive details to the secretary of the association, 25 Madison Ave., New York City.

BUSINESS ITEMS

The Kerr Turbine Co., Wellsville, N. Y., has appointed W. E. Storey as its Toronto, Canada, representative, with offices in the Kent Building. Mr. Storey was formerly identified with the Underfeed Stoker Co., and more recently with Goulds Manufacturing Co.

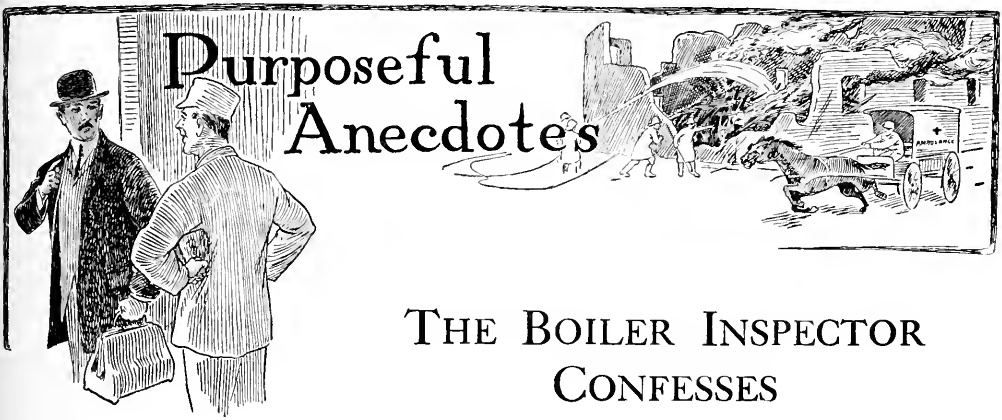
The Nelson Valve Co., of Chestnut Hill, Philadelphia, has issued a revised edition of its twelve page folder entitled "Double Disc vs. Solid Wedge." It contains an interesting history of the development of the gate valve. Copies will be mailed on request

A very attractive circular has just been issued by the Homestead Valve Mfg. Co., Pittsburgh, Penn., illustrating many styles of Homestead Valves. "Here is Your Opportunity to End Your Valve Troubles" is the title. It is being sent to steam users everywhere.

The Yarnall-Waring Co., of Chestnut Hill, Philadelphia, has recently secured an order for "Lea" V-notch meters from the Philadelphia Electric Co., for its great new Christian St. power house, for what is believed to be the largest feed-water V-notch metering installation in the world, comprising two 800,000-lb. per hr. "Lea" V-notch recording meters combined with two 20,000-hp. Webster feed-water heaters and purifiers, to heat and measure 20,000 boiler hp. of feed water. Make-up water for this plant will be measured by a 175,000-lb. per hr. "Lea" V-notch recording meter.

POWER

Vol. 41 NEW YORK, MARCH 9, 1915 No. 10



The Boiler Inspector Confesses

The old boiler inspector looked at me over his glasses with all the seriousness of a strong man approaching the confessional. He WAS going to confess.

° ° ° °

"NO, SIR, I never made half-way inspections. But as a young man I passed conditions I knew were not real bad, but bad enough to warrant giving attention. If a boiler were shut down at such a time, it meant delay. The engineer or the superintendent complained and everybody got a grouch. If I felt that the boiler would go until my next visit, which might be in six months, I'd pass it to make everybody happy. There was nothing seriously wrong in doing this, for if I doubted that the boiler would last until my next visit, it had to be made right, kick or no kick.

"This went on for years. In one plant, the B—— works, I'd thus favored the engineer a few times. The next time I was in the town I was anxious to get over to this plant for I knew the boilers needed inspection. About four o'clock that day and just as I was washing up after I'd finished the A—— company's boilers, Wilkens, the engineer, came rushing into the washroom and asked:

"'Did you hear about it?'"

"'About what?'"

"'Why, two boilers at the B—— works just exploded. They say 14 women were killed.'"

"I didn't reply; I couldn't. My knees shook; I grew hot and cold—I was sick! When I arrived at the works, fire lines had been established and there was a heavy police guard which wouldn't let me through. I looked into an ambulance and saw three forms covered with a sheet.

"Walking around to the next block I got into the yard through an alley. In the débris I hunted for the remains of the boilers, one of which I knew had a thin crown sheet—the sheet I'd inspected and passed. As I stooped to pick up a steam gage, my hand nearly touched an arm, the hand of which bore a wedding ring. I drew back trembling until the dampness at my feet caused me to look down. My shoes were soaked in blood! Oh! but I was sick. I felt worse than a murderer—I had murdered fourteen!

"Nearly crazed, I ran to the street and boarded a car for the hotel. I tried to hide behind a newspaper, but it rustled loudly in my shaking hands. I turned, pretending to look out the window, but the reflection of my face in the glass frightened me more than the staring eyes across the aisle.

"Investigation showed that the fireman had opened the blowoff valve, and before closing it rushed away on a signal from the engineer. Before he returned the explosion had happened. This knowledge relieved my mind, but I had learned my lesson.

"Now I take no chances; I strike the sheets or blowoff pipes solidly. If they are badly corroded, I must know it. Yes, they say I'm too exacting. Some complain to our head office, but I'm going to inspect rightly or I'm not going to inspect at all.

"A good engineer never complains about a thorough inspection. Some poor ones do, but we must protect them against their own shortsightedness."

Salmon River Power Plant

By Warren O. Rogers

SYNOPSIS—The principal features of this hydro-electric development are: A concrete dam 50 ft. high and 675 ft. long, which creates a storage reservoir having a capacity of 2,600,000,000 cu.ft.; two miles of conduit for conveying the water from the dam to the power plant, consisting of a section of reinforced-concrete-lined tunnel, a section of 11-ft. and 12-ft. diameter wood-stave pipe and a section of 11½-ft. diameter steel pipe; a gigantic surge tank 50 ft. in diameter and 105 ft. high, mounted on a structural tower 100 ft. high; four 8-ft. diameter steel penstocks equipped with valves of a new design; the power house, containing four 10,000-hp. horizontal turbines equipped with heavy flywheels, each driving a 6600-kv.-a. generator, together with the transforming, switching and control apparatus; and, finally, a transmission line 42 miles in length operated at 60,000 volts.

The completion of the new Salmon River hydro-electric plant (Fig. 1), of the Salmon River Power Co., located near Altmar, N. Y., and about forty-five miles northeast of Syracuse, has attracted considerable attention to this source of water power, which, with the exception of Niagara Falls, is the greatest in the State of New York.

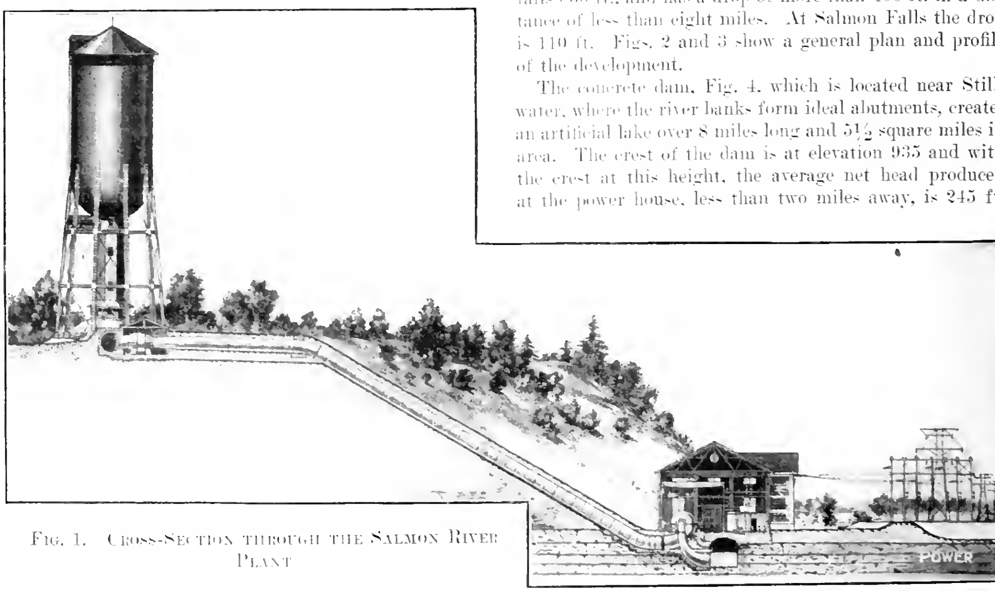


Fig. 1. Cross-Section through the Salmon River Plant

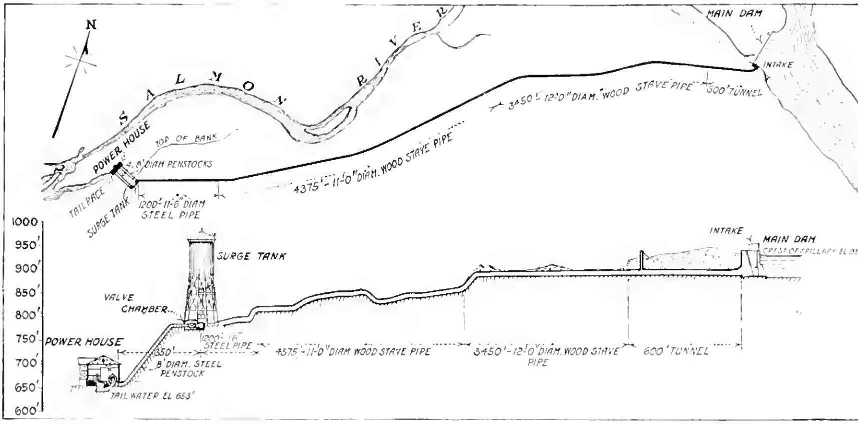
The power from the Salmon River will join that coming from Niagara, as the Salmon River plant has been designed to operate in parallel with the Ontario Power Co., of Niagara Falls. The latter, located in Canada, generates power for transmission over lines owned and controlled by separate and independent companies. All lines in Canada are owned by the Ontario Transmission Co., Ltd., a subsidiary corporation. In the United States the power coming from the Ontario Power Co. is distributed by the Niagara, Lockport & Ontario Power Co., over about 816 miles of transmission lines through the western and central sections of New York State. The latter company has leased the entire property of the Salmon River Power Co. in perpetuity and acquired all its capital stock, thus securing for itself a new source of power at the eastern end of its transmission lines, supplementing that which it now receives from Niagara and from its own steam plants at Lyons and Auburn.

Water Supply

The Salmon River, which is 44 miles long, has its source in the foothills of the Adirondack Mountains and flows through the north-central part of New York State, discharging into the eastern end of Lake Ontario. The river drains a watershed, the tributary area of which is 190 square miles and in which there is an average annual rainfall of about sixty inches. In the 17 miles between Stillwater, where the dam is built, and Lake Ontario, the river falls 650 ft., and has a drop of more than 400 ft. in a distance of less than eight miles. At Salmon Falls the drop is 110 ft. Figs. 2 and 3 show a general plan and profile of the development.

The concrete dam, Fig. 4, which is located near Stillwater, where the river banks form ideal abutments, creates an artificial lake over 8 miles long and 5½ square miles in area. The crest of the dam is at elevation 935 and with the crest at this height, the average net head produced at the power house, less than two miles away, is 245 ft. The dam, constructed of concrete, is 675 ft. long and has a maximum height of 50 ft., with an average thickness of 51 ft. The cubical contents are 30,000 yd.

Water is conveyed from the reservoir first through the intake where the screens and head gates are located, into a 600-ft. section of reinforced-concrete-lined tunnel drilled through the rock and having an internal diameter of 12 ft. The lining of the tunnel is in no instance less than one foot in thickness and is reinforced with circumferential rods closely spaced. From the tunnel the water passes into a 7825-ft. length of wood-stave pipe, 3450 ft. having an internal diameter of 12 ft. and the remainder 11 ft. Fig. 5 shows the manner in which the wood-stave pipe is held circumferentially with ⅞- and 1-in. steel bands. Each band is in three sections, all united by malleable-iron shoes. Where the soil is soft the pipe is supported by timber cradles. At all other points it is laid on the ground and banked with earth. To equalize external pressure when emptying the pipe and to permit air to escape when filling, relief valves are provided at intervals. The lower end of the wood-stave pipe is connected through a specially constructed joint, packed with oakum and lead wool, to a 1200-ft. section of 11½-ft. steel pipe, which conveys the water to the crest of the hill behind the power house. At this point, Fig. 6, there are a number of novel and original features.



FIGS. 2 AND 3. GENERAL PLAN AND PROFILE OF THE SALMON RIVER DEVELOPMENT

SURGE TANK

First, there is a distributor, Fig. 7, which is a 12-ft. steel pipe of ⅝-in. steel plate, 210 ft. long and joined at one end to the pipe line in a huge concrete anchor block, the other end being closed by a bulkhead. The bottom of the distributor is 160 ft. below the crest of the dam. From the center of the distributor a 12-ft. riser branches off to the surge tank, Fig. 8, the largest of its type yet constructed. The surge tank consists of a cylindrical shell 50 ft. in diameter and 80 ft. high, surmounting a bowl bottom of 25 ft. in depth, making a total height of 105 ft. and having a capacity of 1,400,000 gal. of water. It is supported on 10 massive steel columns spaced as shown in Fig. 7, which elevate the bottom of the tank 80 ft. above the ground level. The total height of the complete surge-tank structure is 205 ft.

The thickness of the bowl bottom plates is ⅞ in. and the longitudinal seams are triple-riveted butt-strap joints; the horizontal seams are quadruple-riveted lap joints. The first, or bottom course of the shell, is of 1-in. plate with triple-riveted butt joints. The thinnest plate in the tank is ½ in. thick. The portion of the riser inside the tank is stiffened every 4 ft. by 4x4x½-in. angles to take care of any temporary differences in the elevation of water inside the riser and in the tank proper.

The 12-ft. riser from the distributor connects with the surge tank by means of a special expansion joint. In order that the accelerating or retarding head required to produce the new velocity in the pipe line and demanded by a change in load on the plant may be more quickly established, the 12-ft. riser is reduced to a diameter of 10 ft. inside the tank. This interior riser is flared at the top to a diameter of 15 ft. and terminates 5 ft. below the top of the tank proper. In the annular opening formed between the 12-ft. riser and the 10-ft. riser at the bottom of the bowl, ports have been provided, so that water moving toward the tank flows partly into the main tank and partly into the interior riser, and conversely, water flowing downward through the 12-ft. riser flows partly from the 10-ft. riser and partly from the main tank through the ports.

FIG. 4. SALMON RIVER CONCRETE DAM

The surge tank acts as a hydraulic regulating device for the plant and to protect the long pipe line from shock. When the plant is in operation and a sudden demand for more power occurs, requiring more water, this

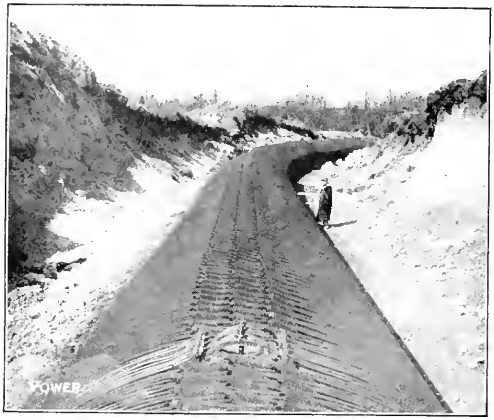


Fig. 5. Twelve-Foot Wood-Stave Penstock

is supplied largely from the surge tank, while the velocity in the pipe line is increasing to the required degree. When the power load is suddenly diminished or thrown off the plant, the surplus water surges into the tank, producing a rapid rise in the interior riser and a slower rise in the main tank. The head produced in the riser checks the velocity of flow in the pipe line and limits the pressure.

If, under very severe and unusual conditions of load change, the water in the riser should reach the top, it would spill over into the main tank and be retained.

The ports at the bottom of the tank are carefully designed so as to introduce just the right amount of resistance to the flow of water to or from the tank proper in order that any surges produced in the hydraulic system by sudden demands for and rejections of power may be effectively damped before serious oscillations in the water column are set up. Also, by the use of this "differential" principle both the maximum head and the required storage capacity in the tank are reduced, making

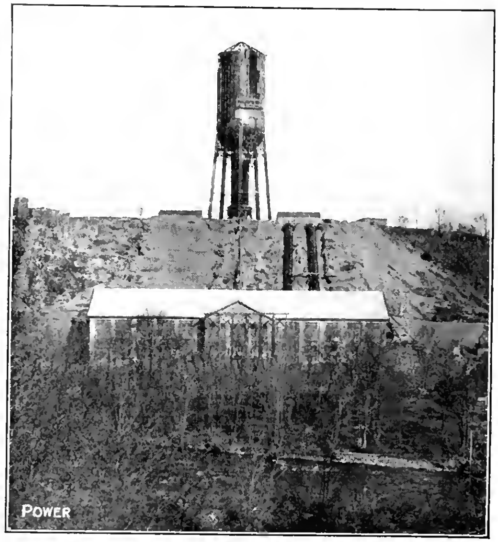


Fig. 6. Surge Tank on Hill Back of the Power Plant

possible lower construction costs and better hydraulic regulation.

Another interesting feature in connection with the surge tank is the provision which has been made to prevent freezing. The tank is housed in with a framed wooden structure, which provides a series of air spaces

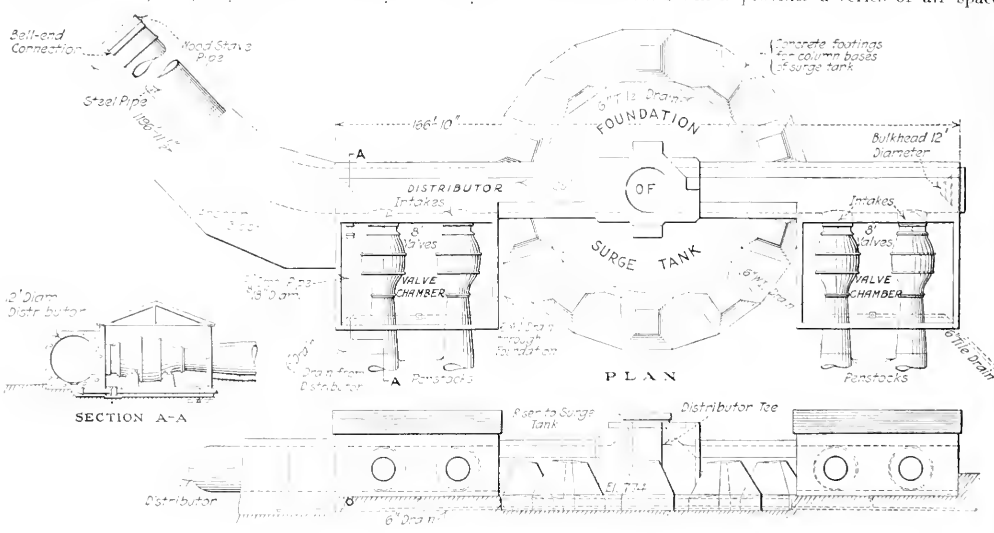


Fig. 7. Plan and Elevation of the 12-Ft. Distributor

through which warm air is blown whenever necessary by fans located at the base of the tank.

Hydraulic Valves and Penstocks

Four 8-ft. penstocks are connected to the distributor through hydraulic valves of a new design. The normal head under which these valves operate is 154 ft. An exterior view of one of the valves is shown in Fig. 9; a sectional view in Fig. 10. The valve consists of a casing which supports an internal stationary shell *A*, headed against the flow of water, as indicated by the arrow. A hollow movable plunger *B* carries a bronze ring *C*, which seats against a ring *D*. The movement of the plunger is controlled by a four-way valve and suitable piping. The pipe *E* is connected to the penstock on the intake side of the valve, the pipe *F* is piped into the space behind the plunger, *G* into the space between the plunger and the shell, and *H* discharges to the air.

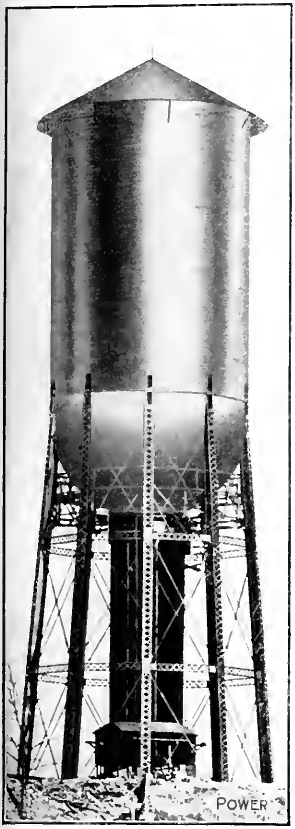


Fig. 8. Near View of the Surge Tank

To close the valve the pressure in the pipe *E* is put in communication with the pipe *F*, and pipe *G* with *H* by means of the four-way valve, thus putting pressure behind the plunger and gradually closing the valve. When opening the valve the pipe *E* is put in communication with *G*, and *F* with the pipe *H*. The plunger can be stopped at any point between its full open and closed position, its exact position at any time being designated on the indicator shown in Fig. 9. The four-way valve is either hand or motor driven and can be electrically controlled from the main switchboard in the power house. In order that the switchboard operator may know that the valve is operating properly, a pilot lamp, controlled by suitable contacts on the valve indicator, is installed on the control switchboard in the power house.

From the valve chambers four 8-ft. steel penstocks, which are anchored above and below in heavy concrete blocks and laid in trenches which are back-filled, run to the power house. Two are seen in Fig. 6, as they had not been covered with earth at the time the photograph was taken. The thickness of the steel plate of which the penstocks are constructed varies from $\frac{1}{2}$ in. on the upper horizontal end to $\frac{7}{8}$ in. at the lower end, where they enter the power house.

Power House

The power house is constructed of reinforced-concrete columns connected with heavy concrete beams. The panels around the large window areas are filled on the inside with sand-lime brick and with red brick on the outside. The building is rectangular, with a projecting feeder bay. In the feeder bay and along one side of the main generator room is a gallery about 12 ft. above the main floor. A 10-ton electric crane, with main and auxiliary drive of 250-volt direct-current motors, spans the generator room, which is 38 ft. wide.

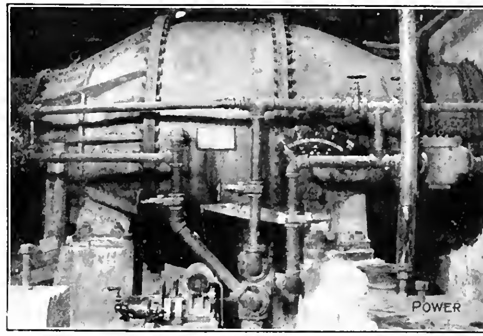


Fig. 9. An 8-Ft. Johnson Penstock Valve

All intake pipes, draft tubes and discharge tunnels are under the building, embedded in or formed of concrete which rests on solid rock; the arrangement of this is shown in the plan and elevation views, Figs. 11 and 15.

Main Units

There are four turbines of 10,000-hp. normal rating of the Francis horizontal, single-spiral, double-discharge type, which are provided with outside-balanced wicket gates operated by hydraulic governors.

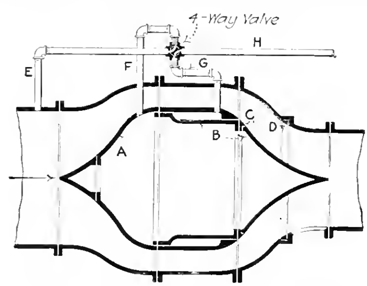


Fig. 10. Sectional View of the Penstock Valve

The turbines have guaranteed efficiencies of 82 per cent. at full load, 85 at three-quarter load, 80 at half load and 70 at quarter load. On the turbine shafts are mounted heavy flywheels to assist in governing and to facilitate the operation of the electrical equipment of the plant in parallel with other plants on the transmission system. Relief

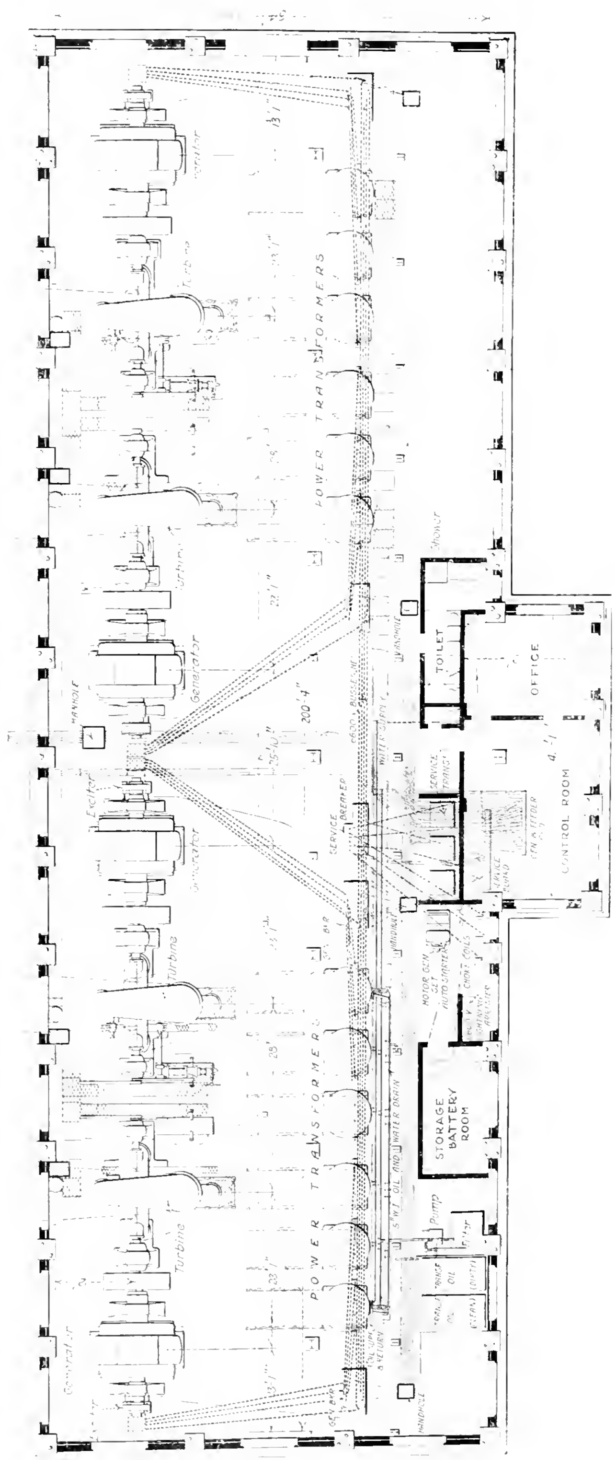


Fig. 11. Plan of the Power Plant Showing the Arrangement of the Main Units and Accessories

valves on the turbines, operated by the governors, prevent excessive pressure rises upon sudden closure of the turbine gates. Nos. 1 and 2 units are shown in Fig. 14.

The hydraulic governors, Fig. 12, are adjusted to permit of not more than 15 per cent. increase in speed above normal on the sudden removal of the full load carried by the generator, 6 per cent. for half load, 3 per cent. for quarter load and 1.5 per cent. for one-tenth load.

The turbines discharge into a tailrace through short concrete draft tubes, entering at an obtuse angle to prevent eddies. The tailrace is under the power house, which is built over the bed of a branch of the river. The exit of the tailrace from the building is closed by a curtain wall which prevents the ingress of cold air.

The four generators directly coupled to the turbine shafts are 6600-kv.-a. capacity, 6600-volt, 25-cycle, three-phase units. The exciter of each machine is mounted on an extension of the shaft, Fig. 14, and is adapted to voltage and power-factor control by a voltage regulator. The pole faces of each generator are provided with damping grids. The generators are of the semi-inclosed type, and the cooling air is discharged through a large opening in the top of the casings. They are designed to operate either as generators or synchronous condensers, in order that they may be used both for generating electrical energy and for power-factor correction on the long transmission line from Niagara. Each is designed to carry 20 per cent. overload and is also capable of operating at full current output up to 7500 volts. The limits of voltage regulation allowed at normal kv.-a. load were for 100, 90 and 80 per cent. power factor, 12, 25 and 28 per cent., respectively.

Station Electrical Equipment

The electrical equipment for each generator further consists of three 2200-kv.-a. single-phase, 25-cycle, oil-cooled transformers, Fig. 13, with a normal ratio of 6600 to 34,650 volts, the high tension in star giving 60,000 volts on the line; a 6600-volt, 1200-amp., triple-pole, single-throw circuit-breaker, automatic for reverse power, and the necessary connecting cables and auxiliaries. The duplicate high-tension busbars are hung from the roof, over the gallery, upon which are located the high-tension line and the transformer circuit-breakers and line choke

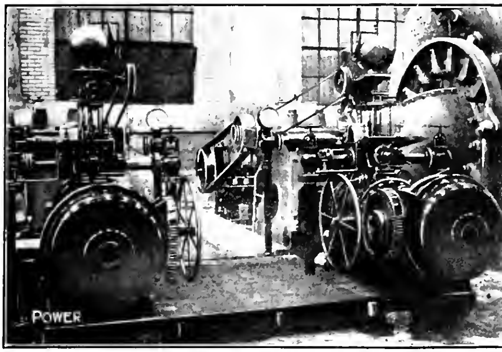


Fig. 12. Hydraulic Governors

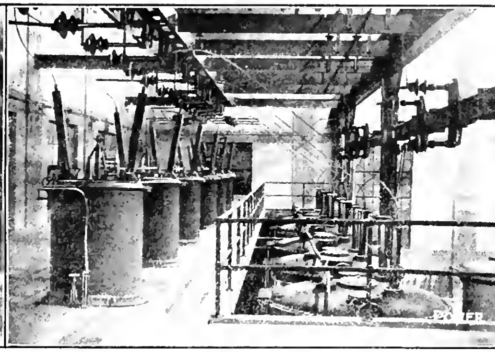


Fig. 13. Oil-Cooled Transformers

PRINCIPAL EQUIPMENT OF SALMON RIVER POWER PLANT

No	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Turbines. .	Horizontal single spiral	10,000-hp	Main units	375 r.p.m., 245-ft. head	Wellman-Seaver-Morgan Co
4	Generators.	Alternating current	7920-kv.-a max	Main units . . .	375 r.p.m., 6600 volts, 25 cycles, three-phase . .	Westinghouse Electric & Mfg. Co.
4	Generators. .	Direct current	150-kw	Exciter units	375 r.p.m., 125-245 volts	Westinghouse Electric & Mfg. Co.
4	Governors . .	Lombard		Speed-control, main units	Belt-driven from generator shaft	Lombard Governor Co
1	Surge tank	Differential	50x105 ft., 1,400,000 gal.	Regulation of pipe line		The Kennicott Co
4	Valves. . .	Balanced hydraulic	8-ft.	Controlling penstock water	Hydraulically operated, electrically controlled . . .	Wellman-Seaver-Morgan Co
1	Crane. . . .	Electric	40-ton.	Generator room	Motor-operated . .	Shaw Electric Crane Co
12	Transformers. . .	Oil-cooled	2200-kv.-a. . .	Generator to line voltage	Single-phase, 25-cycle, 6600-60,000 volts	Westinghouse Electric & Mfg. Co.
4	Circuit-breakers	Single-throw	7920-kv.-a . . .	Between generators and transformers	6600 volts, 1200 amperes	Westinghouse Electric & Mfg. Co.
4	Circuit-breakers	Single-throw	7920-kv.-a	Between transformers and high-tension bus	60,000 volts, 100 amperes	Westinghouse Electric & Mfg. Co
2	Circuit-breakers	Reactance type. . .	32,000-kv.-a	Between high-tension bus and line .	60,000 volts, 300 amperes	Westinghouse Electric & Mfg. Co.
3	Transformers. . .	Self-cooled.	100-kw.	Station service.	Delta-connected, 6600 to 2200 volts. . . .	Westinghouse Electric & Mfg. Co.

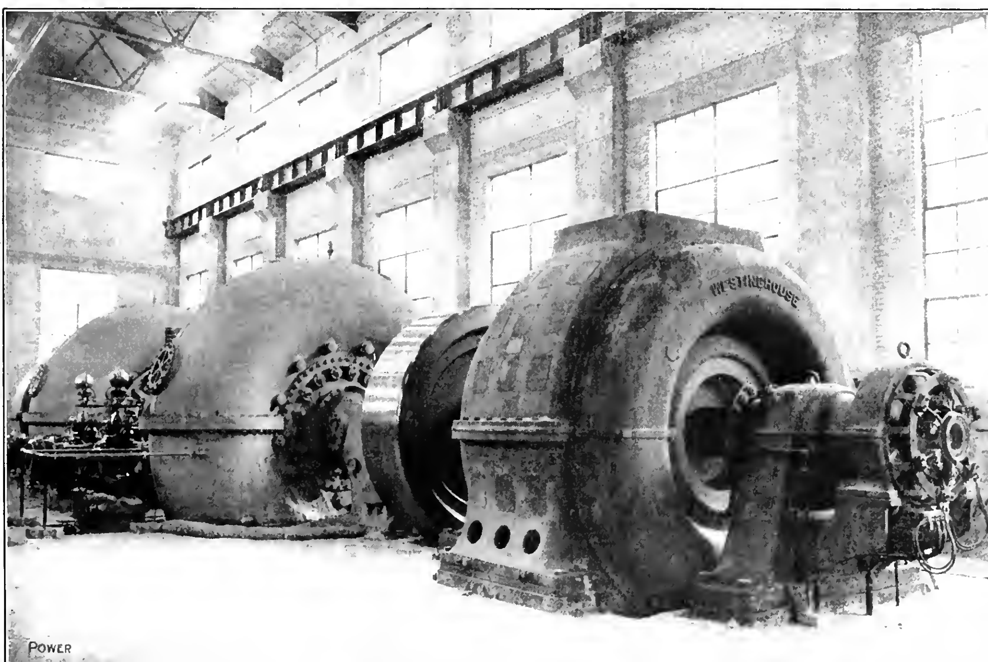


Fig. 14. Two of the Four 10,000-Hp. Turbines and 7290-Kv.-A. Generators

coils. Directly under the buses are the necessary disconnecting switches.

For station service there are three 100-kw. self-cooled transformers which step the voltage from 6600 down to 220 volts. They are delta connected on both sides.

On the main floor, under the gallery, are the generator circuit-breakers, main and service transformers and a storage battery for switch operation. The control switchboard is on the lower floor of the feeder bay, and is of the vertical panel, remote-control type.

Transmission Line

The transmission line from the power house to the substation of the Niagara, Lockport & Ontario Power Co., at Solvay, N. Y., is about 42 miles long and comprises two circuits carried on steel towers with suspension insulators.

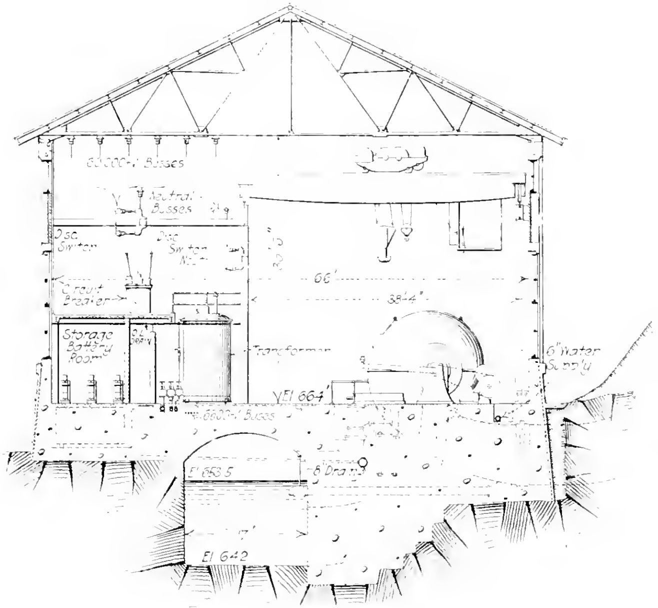


Fig. 15. Elevation of the Power Plant

The plant was first put into commercial operation in April, 1914, with two units running. The third and fourth units were placed in service in October, 1914, and the plant is now carrying a maximum load of 23,000 kw.

The engineering work was carried on under the direction of V. G. Converse, chief engineer of the Salmon River Power Co. Messrs. Barclay Parsons & Klapp had charge of the engineering and construction of the dam, and also acted as consulting engineers for the entire work.

Human Energy in Electrical Units—On an average a man dissipates about 2.5 kw.-hr. per day. This is spent partly in muscular action, partly in the production of heat in the maintenance of the body temperature against radiation. There is thus a continual power consumption of about 100 watts, or one-seventh of a horsepower. About one-half of this is spent in maintaining the body temperature. The human body has about the same heating effect upon the surroundings as a 16-cp. carbon filament lamp.—"Scientific American."

A Low-Pressure Turbine Manifestation

By Ide L. Benedict

Instances are frequent where power-plant machinery has been improperly selected. This may not have been the result of ignorance or misrepresentation, but of failure to give due consideration to the probable operating conditions. Cases of the installation of units of incorrect size are probably more numerous than those in which an unwise choice of the type of prime mover has been made. It would seem that we rely too much upon attaining ideal conditions, when estimating the performance of a new type of machine. There may sometimes be good reason for this and the expectation is realized. On the other hand the conclusion may have been reached from a superficial survey of the operating factors, and the actual results fall far short of the prediction. Examples can be cited of new gas-engine installations of excellent operating record which were soon displaced by steam turbines on account of the rapid increase in the price of gas.

On the advent of the low-pressure turbine too much was expected of it, not only in effecting a remarkable saving in fuel consumption, but also in providing a new lease of life, from an economical viewpoint, for existing engine equipment. While the majority of the low-pressure turbines have been economic successes, there are one or two exceptions from which a lesson may be drawn

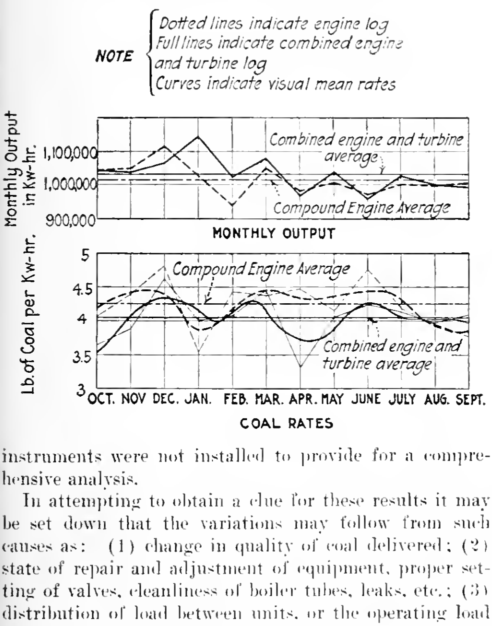
First, the low-pressure turbine is dependent upon a favorable vacuum being maintained, and secondly, a good load must be carried upon the unit. Otherwise the potential economy is sacrificed.

The accompanying curves, taken from the records of such a low-pressure turbine plant exemplify this phase of power-plant engineering and operation. The average saving in coal consumption throughout the year was somewhat less than 4 per cent., representing a reduction from 4.25 lb. to about 4.1 lb. per kilowatt. Under favorable conditions, the low-pressure turbine should effect an improvement of over 25 per cent. and lower the coal rate to 3 lb. or better. An analysis shows that the load is a widely swinging one and the fluctuating condensing-water conditions preclude high vacuum being regularly maintained. Furthermore, the power consumption of the condenser auxiliaries is abnormal on account of the rise and fall of the water-supply level, and as the station furnishes only a direct-current output and the turbine is coupled to an alternator, converting machinery with its attendant losses is required. So the operation of the low-pressure turbine is prejudiced, and it would be an unfortunate commentary upon this type of prime mover if all of these controlling factors were not made clear.

As will be observed, the load on the plant did not vary sufficiently to have any appreciable bearing. The difference in coal rate from month to month is partly explained by the irregularity with which coal is received.

The curves show twelve months preceding and twelve months succeeding the installation of the low-pressure turbine. Some theories may be advanced as to the reason for the apparent irregularities. The high coal rates obtain at about the same time as the heavy load. As a station's economy should ordinarily improve with an increase in output, the cause for the variation may be due to engines pulling loads at long and uneconomical points of cutoff, or the hand-fired boilers may have been forced to a point where their efficiency fell off rapidly.

Sometimes the winter coal rate will increase on account of the greater radiation losses and the introduction of colder air into the furnaces, if the condensing equipment is not capable of operating on a low-terminal temperature difference, and therefore does not utilize the benefit of the low circulating-water temperatures. But apparently, these circumstances do not exert much bearing in this case. Sufficient measuring and indicating instruments were not installed to provide for a comprehensive analysis.



In attempting to obtain a clue for these results it may be set down that the variations may follow from such causes as: (1) change in quality of coal delivered; (2) state of repair and adjustment of equipment, proper setting of valves, cleanliness of boiler tubes, leaks, etc.; (3) distribution of load between units, or the operating load factor of the different units; (4) the efficiency of the operators during the periods under comparison.

Visual mean curves have been drawn so as to counterbalance the irregularities in billing the coal and other charges from month to month. The coal rates when running with and without the low-pressure turbine approach each other closely except in April, when a happy set of conditions seems to have been hit upon in the operation of the low-pressure turbine. As compared with the noncondensing engine, the economy of the low-pressure approaches the proper point, taking the maximum dip of the solid line, while in the month of August the comparison is somewhat startling. The station is subject to a rapid swinging of the load over 15 per cent. either side of the mean, and this no doubt has an important effect upon the coal consumption.

The way in which the load divides between the engines and the turbine may account for a good part of the discrepancy, particularly as the entire output of the low-pressure turbine, which is direct-coupled to an alternating-current generator, must flow through a motor-generator set, with a loss of 20 per cent. or more, depending upon the load carried.

Oil and scale on the blades of the turbine would noticeably affect the ultimate economy, but during the period under discussion the turbine was in good condition.

The unit under consideration is of 1000-kw. capacity; steam pressure carried, 150 lb. gage; and vacuum sought, 28 in. (30 in. bar.), though it ranges around 27 in. and less.

In view of this development, which might have been foreseen had these conditions been reckoned with, the natural inquiry is what would have been the most appropriate machine to have installed? The plant was equipped with single-cylinder Corliss engines. Undoubtedly, a straight condensing turbine would have best satisfied the requirements and provided a unit *per se* modern, and would have obviated the perpetuating of the use of the reciprocating engine, as has become necessary with the installation of the low-pressure turbine. Besides, floor space might have been economized, and it would also have made it simple to carry out further extensions both in consistency of type and arrangement.

One thing that should lead to careful consideration in engineering work is that any failure to fully regard all governing conditions will probably be cast up later as a display of lack of ability, and consequently the installation becomes a conspicuous error.

Redesigned Barton Expansion Steam Trap

This thermostatic trap was described in the April 25, 1911, issue of POWER, and was then manufactured by John W. Barton, Cleveland, Ohio. It has been slightly redesigned, and is now manufactured by the Automatic Steam Trap & Specialty Co., Detroit, Mich. The former trap consisted of an inner and an outer expansion tube and a casing holding the two heads. The redesigned trap has but one inner brass tube, an outside steel tube and a valve. A short extension screwed onto the brass tube seats against a flat disk, which is adjustable for different temperatures of steam. In other respects the trap is the same as the original one. The brass tube is free to expand and as its length increases more rapidly than that of the steel tube, when heat is applied it will seat against the disk. Reinforcing rings around the brass tube tend to prevent buckling.

When the trap is first installed the disk is adjusted so that the valve will close when the brass tube is full of steam. When this steam cools into water the brass tube shortens, pulls away from the valve disk and allows the condensation to escape. Steam following the water again expands the tube and closes the valve. This operation is repeated, and the system to which the trap is attached is kept free of water.

Anthracite—When the first two tons of anthracite coal were brought into Philadelphia in 1803 the good people of that city, so the records state, "tried to burn the stuff, but at length, disgusted, they broke it up and made a walk of it." Fourteen years later Col. George Shoemaker sold eight or ten wagon loads of it in the same city, but warrants were soon issued for his arrest for taking money under false pretenses.

Suggestions on Overhauling a Refrigeration Plant

By Thomas G. Thurston

SYNOPSIS—An article alive with practical suggestions for finding the weak and the leak spots in a refrigeration system, and putting the plant in good condition for the next season's run.

The time is here when the demand on the refrigerating system is lowest. Preparations should be made for the time when part or all of the system can be shut down for repairs to put it in good condition for next season's run.

Notes should be made of the defects and troubles that have been contended with during the season and steps taken to remedy them. Joints that cannot be kept tight with reasonable tension on the bolts should be marked for attention when the system is shut down. Leaky valves should receive the same treatment. If the ammonia charge is loaded with oil and impurities, pump it out and have it purified.

The Ammonia End of the Compressor

Open and go over every part of the compressor: Examine the cylinder for shoulders and score marks; see that it is round and of uniform diameter throughout its length. Examine the piston and rings and see that the former is a snug fit in the cylinder and that the rings fit in the piston grooves. See that the rings have sufficient tension; if they have not they can be peened out a little with a hammer, although this is a makeshift. Examine the connection of the piston to the rod and make sure it is firm. Caliper the piston rod and if it is worn or scored have it turned or replaced with a new one.

If the old rod is turned, be sure and make a junk ring for the bottom of the stuffing-box to keep the packing from squeezing out between the smaller rod and the bottom of the box. If the rod is much smaller than the original the stuffing-box gland should be babbitted to about one-sixteenth inch larger than the rod.

If the machine has false heads inspect them and the seats for score marks and signs of ammonia blowing through. Grind them in with emery or powdered glass and oil, or, if they are too bad, they will have to be faced first.

Go over the valves, seats and cages thoroughly. If the valves and seats are not much worn they can be ground in; otherwise, get new ones. See that the valves fit snugly on the guides and that the springs have the proper tension. The correct spring tension can best be determined by the indicator. Any other way is merely guesswork.

In most designs of valves there should be a small hole in the valve or guide to let the latter act freely. If this opening is neglected the gas in the valve or guide will compress or form a vacuum, depending on which way the valve is moving, and interfere with its free action.

Examine the check valve in the discharge; see that it seats properly; grind the valve in or rebabbitt the disk if necessary; be sure that it does not fit too loosely on the guide, for if it does it may hammer and will not seat properly. Clean, oil and grind in the relief valve and see that it works freely. If the suction line has an automatic check valve in it, this should be cleaned and oiled and the valve and seat examined.

Some plants have an elaborate system of piping for oiling the stuffing-boxes and for relieving gas from them. These should be cleaned, as they generally accumulate packing and dirt. Clean out the oil separator; if it cannot be opened it can be fairly well cleaned by blowing it out with a steam hose. Clean, oil and test all the gages. Test all the thermometers if any are used.

The Steam End of the Compressor

The engine cylinder, piston and rod should receive the same attention as similar parts of the compressor. Examine the valves and valve gear thoroughly. Caliper the crosshead guides, and if they are much more worn in the center than at the ends, have them bored or planed. If the crosshead shoes are badly worn they should be babbitted. Caliper the crosshead pins, and if they are not round, have them turned. They may be dressed with a file. See that they fit tightly in the hole in the crosshead. While the machine is dismantled run a line through the cylinders and see how the cylinder guides and main bearings align.

Take the main bearings apart, clean them and see that the oil grooves are open and sufficiently deep. Examine the cranks to determine if they are loose on the crankshaft, or if the crankpins are loose in the disk. When the crankshaft is placed in the bearings be sure to adjust the quarterboxes so that the shaft will line up with the cylinder. After the engine is assembled, adjust the clearance on both the compressor and engine. On an engine and a double-acting compressor this is practically fixed; on a single-acting machine the clearance is adjustable and should be set as close as possible consistent with safety. Some operators have run the piston clearance as low as $^1/_{64}$ in., where the machine is equipped with false heads. The writer believes it should never be less than $\frac{1}{16}$ in.

The Condenser

The condenser should be examined before it is shut down, and all joints that have caused trouble by leaking should be marked. This applies to the joints that may be tight, but have been drawn up with more than a reasonable tension on the bolts to keep them tight. Leaky valves should also be marked. Open a few of the coils, and if there is much oil or foreign matter present they should be cleaned.

Make a steam connection to the gas header, shut off all the gas valves, open the ends of the liquid header or disconnect the coils altogether. Then blow out the coils one at a time by turning steam on the header and opening the gas valves in succession until the oil and foreign matter are blown out. When this is done disconnect the steam connection and pump about 100 lb. of air pressure on the header and blow the coils as before.

Clean the scale and mud from the outside of the pipes with a wire brush if it is an atmospheric condenser. If it is of the double-pipe type remove the return bends and clean the inside of the pipes with a tube scraper or a turbine cleaner. Open the water headers and clean out the sand and scale that have accumulated in them.

Remove the bonnets from the valves on the gas liquid line and pump out headers. Examine the seats and disks and if they are scored or show signs of blowing through or the babbitt is squeezed out, they must be ground in or rebabbitted. Renew the gaskets on all the bonnets. If it is important to keep the machine running continuously during the season, renew the gaskets between the valves and headers unless certain that the gaskets are in good condition and will not blow out if they start to leak, but may be drawn up without undue strain on the bolts.

The gaskets between the valves and the individual stands are not so important, as a blowout on this side of the valve puts only one coil out of service. For this reason the gaskets between the valves and headers should receive particular attention. If a gasket blows out between the stand and valve or any place in the stand, it is only necessary to shut off the gas and liquid valves, pump out the coil and repair the blowout, when convenient to do so. In the meantime the rest of the condenser may be kept in operation. For this reason it is also important that the valves be tight. The gaskets in the headers should also receive the same attention.

Renew the packing on all the valve stems, also the gaskets in all the leaky joints. Draw up all bolts and if any are rusted so they cannot be turned with reasonable effort, replace them with new ones. Inspect the pipes and headers thoroughly for pitting and corrosion, especially at the water and ammonia joints. If any of them are badly eaten away put in new ones.

Testing for Leaks after Repairing

After everything has been thoroughly examined and repaired, pump an air pressure on the condenser a little higher than the maximum head-pressure carried. This will show bad leaks or joints that have not been tightened. Make thick soapsuds and apply with a brush to all the joints under pressure. Leaks will be indicated by the formation of soap bubbles. After all the leaks that have been found are taken up, pump the pressure up again, shut the discharge valve on the machine and see that the bypass valves are tight, also the blowoff valve on the oil trap and other connections to the discharge line. If there are no leaks and all the valves are tight, the pressure should hold for a long time. If the pressure falls rapidly there is a valve open somewhere or a bad leak, and this must be found.

If the pressure falls gradually, a few pounds an hour, it is generally caused by small leaks that will take up after the condenser is in operation or can be found with a sulphur stick after the ammonia is turned into the condenser.

After the high-pressure test, let the air out of the condenser and pump a vacuum on the latter and let it stand for several hours to see if it will hold; sometimes a line or coil that will stand a high-pressure test will not hold a vacuum for even a short time. About the only way to locate these leaks is to hold a lighted candle to the suspected joint; if it leaks the flame will be drawn in. If the vacuum test is satisfactory, pump all the air possible out of the condenser, and turn the ammonia into it immediately (to keep air from leaking in), until the pressure comes up to five or ten pounds. Now go over every joint with a sulphur stick.

Leaky Water Pipes in Condenser

Tests must now be made for leaky water pipes if it is a double-pipe condenser. The return bends must be off and the sulphur stick held in front and at both ends of each pipe in succession. Corroded pipes must be replaced by new ones.

When the leaks have all been attended to, pump full pressure on the condenser and test it again. If this test is satisfactory put on the return bends and test these and the water headers with water pressure.

Expansion Coils

Unless one is certain that there is no oil present in the expansion coils, it is better to open a few of them and investigate. If there is oil it should be blown out. Make a steam connection to the coils, disconnect all the coils in the case of a brine tank, and first blow each out with steam. If it is desired to remove every trace of oil, pump a solution of caustic soda through the coils after blowing them. In either case they must finally be thoroughly blown out with air.

Renew the gaskets on all the joints opened and tighten the rest. Go over the suction and expansion valves and repair those that may require it. If brine tanks are used, clean them out thoroughly. Pipe hangers and supports around a brine tank deteriorate rapidly and should be looked after. Any of the headers on the liquid or suction sides of the tank that have caused trouble by leaking should be attended to. After the coils have been cleaned, test them as the condenser was tested, although it is not necessary to use as high pressure.

Lines and Auxiliaries

Joints in the lines that have caused trouble during the season should have the gaskets renewed. Remove the bonnets from the stop valves and examine the seats and disks. Note the position of the valves in the line. Nearly all ammonia valves are of the globe or angle type and should be placed in the line so that the flow will lift the disks off their seats in case they come loose from their stems. If the valve is placed in the line in the reverse position and the disk comes loose from the stem, it will act the same as a check valve and stop the flow. This is dangerous, especially in a discharge line. Inspect the lines for pitting and corrosion. If any are rusted badly they should be renewed; if any of the liquid or suction lines are uninsulated they should be covered; if the liquid receiver is in the engine room it also should be covered.

Inspect the brine pump closely for pitting and honeycombing in the surfaces exposed to the action of the brine. The writer remembers one case where the wall between two valve chambers became so weakened from this cause that a large piece blew out and disabled the pump.

A High Boiler Pressure is to be carried on the battleship "Nevada," now nearing completion—295-lb. gage. Oil-fired Yarrow-type boilers will be used.

Retubing Tubular and Water-Tube Boilers

By J. C. Hawkins

SYNOPSIS—Simple and thorough directions for taking out and putting in tubes in various kinds of boilers. What troubles to expect when expanding and beading tubes. How to get a bagged tube through the tube sheet. The use of tools to do this kind of work.

Renewing Tubes in Horizontal Tubular Boilers

The location of the tube to be renewed will govern to some extent the procedure in getting it out. If the tube can be taken out at the lower manhole it can be cut off at both ends inside the heads with a bent chisel or with an inside tube-cutter, Fig. 2. The bead on the outside of the sheet is then cut off with a chisel and the tube ripped through the seat. The ripper, with dimensions, is shown in Fig. 1. In ripping the tubes the workmen should be careful not to cut the tube seat. After the cut is made the ends are closed, Fig. 3, and the piece knocked out. If the tube cannot be taken out at the manhole it must come out through the tube hole.

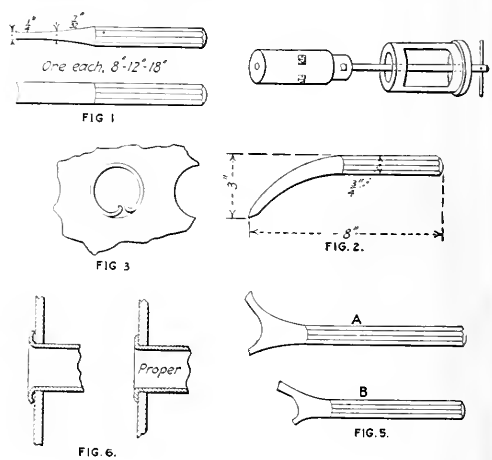
Tubes are usually covered with hard scale and are sometimes bagged or blistered, so it may save time to run the tube-cleaner through the tubes to be taken out. When a tube is to come through the tube hole it is not cut inside, but the ends are ripped and closed up and the tube forced out through the hole.

This may be done in many different ways and the one to be chosen will depend chiefly on the condition of the tube. It may be forced out a few feet with a sledge-hammer and a block of hard wood on the back end, but there is but little room at the back chamber to insert a long block or bar to drive it out. It may be possible to get a flat bar down between the tubes by getting on top of them and swinging the bar against the end of the tube. A chain hoist or block-and-fall hitched to the projecting end of the tube and to the wall will help. If the tube is badly scaled, striking it with a hammer close to the head will help to knock off the scale. Sometimes, turning the tube with a pipe wrench or chain tongs will screw it out of the sheet, especially if a chain hoist is attached to the end to pull it along. After it has been forced part of the way out the projecting end can be cut off with a pipe cutter and a new hitch taken on the remaining part.

As the back end will be battered up in driving the tube out it will not come through the hole without being closed up; this can be done from the outside with a hammer and chisel. Often, more damage is done to the tube hole in getting an old tube out than by working the boiler several years. After the old tube is out the seat is cleaned and the new tube slipped in. Some engineers recommend that the ends of new tubes be annealed in a charcoal fire before putting them in, to make them more homogeneous and prevent them from cracking while being expanded. This is not necessary if precautions are taken to put the tube in properly so that it will not be stretched excessively in expanding.

In some fire-tube boilers copper ferrules are used to fill the space between the tube and the sheet. This is not necessary unless the tube hole has been stretched by repeated expanding. Strips of copper or copper ferrules should be used to fill the space. Whatever the material, it should be softer than the head to prevent stretching the tube sheet. Copper gives the best results. The tubes in a fire-tube boiler should project through the head about one-quarter inch on each end to allow for beading after the tube is expanded. If it extends more than this, the tube is likely to be cracked in beading over. The ends should be expanded tight before beading. Before starting to expand the tube, see that both ends extend through the proper distance, then have a helper hold the front end tight with a bar to prevent it from slipping while the other end is being expanded. In placing the expander in the tube care should be taken to have the rolls extend an equal distance at the sides of the sheet and that the tube expands gradually all around to prevent splitting.

There are two types of expanders—the prosser and the roller, or dudgeon, Fig. 4. The former does its work by a turned taper wedge being driven into the center of a block made up of a number of wedge-shaped sections. The roller expander, which gives the best results and is generally used, consists of a frame carrying three steel



Tools for Cutting and Beading Boiler Tubes

rolls forced out against the tube by a taper plug. The plug is tapped lightly to set the rolls out against the tube and is turned to roll the tube against the seat. If the tube hole is not round the tube will be expanded tight into all the cavities by the roller.

One difficulty sometimes encountered by an inexperienced man in using the roller expander is that when the tube is a loose fit the plug is driven in snug at the start. This will tend to stretch the tube at three points, and when turning the plug the rolls will not move out of these spots. If this occurs the rolls will have to be loosened, set in a different place and the tube gradually rolled until these spots are worked out. Sometimes this causes much trouble, but if the plug is tightened gradually as it should be, no trouble will be given.

Sometimes the workman is at a loss to know when to stop rolling. As soon as the tube is rolled out tight the rolls will seem to be turning on a smooth surface and the plug will be tight when tapped with a hammer. It is best to stop at that time and examine the joint. If there appears to be spots that are not rolled out tight the expander should be used again. Afer the tube is expanded the ends should be beaded over flat against the head. This can be done best with a beading tool, Fig. 5. The bit of these tools should be about 3/8 or 1/2 in. wide. Tool *A* is used first to draw the edges over, striking lightly to prevent splitting, and *B* is used to draw it down flat against the tube sheet. Fig. 6 shows proper and improper beading.

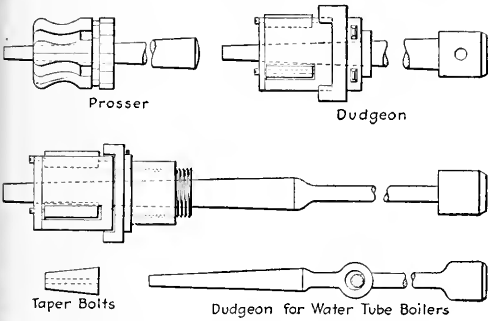


FIG. 4.

TUBE-EXPANDING TOOLS

Replacing Tubes in Water-Tube Boilers

Water-tube boilers are built in so many different shapes that no rule applies to all boilers. In the Babcock & Wilcox, Heine and some others of similar design, all the tubes except those in the bottom and top rows will have to come out through the tube hole. Those in the bottom row usually have to be replaced much more often than the others.

The easiest way to get out a bottom tube is to cut it at both ends with the ripper, Fig. 1, made long to extend through the water leg and close the ends up. The tube may then be cut in pieces and easily taken out by cutting it in the furnace near the bridge-wall and again back of the bridge-wall. If the boiler has horizontal baffles on the lower tubes it need not be cut. The most convenient way of cutting a tube is with the five-wheel pipe cutter, Fig. 7, but it may be done with a plain three-wheel cutter by turning the tube with chain tongs. Tubes above the bottom row must come out through the tube hole.

It is a hard job to get bagged tubes through the tube holes. If the enlarged part can be reached with a long chisel between the tubes it may be split and closed up to go through the header. After being driven as far as possible from the back end it will have to be treated in the same way as in fire-tube boilers. It has been necessary, where the tube was badly bagged, to put a clamp on and use a jackscrew on each side to get it out.

Tubes in water-tube boilers are not beaded as in fire-tube boilers, but are "belled" or flared out; that is, expanded to greater than the original diameter outside the header. This is done by first expanding the tube in its seat, then pulling the rolls out so that the end projecting beyond the header, which may be from 1/4 to 3/4 in., will be expanded to a diameter about 1/4 in. larger than the tube. In putting in the new tube care should be taken to replace the baffle brick, which may fall out when the old tube is removed. The best expander for water-tube boilers is made as shown in Fig. 1. This is similar to the plain dudgeon, but the end which carries the adjusting collar enables the collar to be set at any distance from the rolls. The advantage of this is that the center of the rolls may be set over the tube seat irrespective of the distance the tube projects through the header. The plug used in this expander is made long enough to extend through the header to give plenty of room for operation.

The tubes in the vertical boilers of the Wickes and Cahall type are removed through handholes in the head of the steam drum and the new tubes are put in in the same manner as in horizontal water-tube boilers except that the tube must be blocked up in place in the mud drum while the upper end is being expanded and belled.

In Stirling boilers the tubes are so spaced (except in some of the older types) that any tube may be taken out without disturbing any other tube. A Stirling boiler of given horsepower may be high and narrow or low and wide. As the tubes are not all the same shape or length, it is necessary to order them from the makers, stating the type and size of the boiler and for which row they are wanted. The rows are numbered from back to front, No. 1 tube being the one nearest the back wall between the back drum and the mud drum, No. 2 is next toward the grates, etc. They are numbered in the opposite direction to the flow of gases.

To get these tubes out, rip the ends about six or eight inches at the lower end and four inches at the top end. Close up the end and push it down into the mud drum until the top end comes out. Swing it around and pull it out, then twist it around until it will slip out between the other tubes and through the door in the setting. This is sometimes quite a puzzle, but unless the tube is badly warped it will come out easily. The new tubes are marked "Top" on the end that goes into the steam drum and can be put in only one way. Each is also marked with the number of the row in which it belongs. Roll them in as mentioned. They must be blocked up in place and the top end rolled, first being particular to get the bend in line with the others. If this is not done trouble will be experienced in taking out the tube next to it. The first two or three rows next the fire are most likely to give trouble and are generally badly warped. These tubes should be belled in expanding, not beaded.

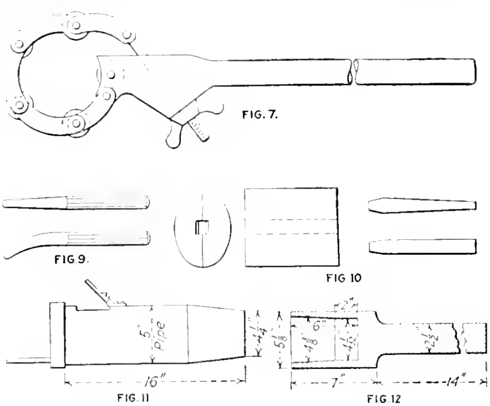
In any boiler where the seat is in good condition and the tube properly expanded there is small chance of leakage, but as a precaution the boiler should be given a hydrostatic pressure test at one and one-half times the working pressure.

Calking and Riveting

Each time the boiler is out of service the tube ends and joints should be examined for leakage, which usually shows as a grayish-white substance on the fire side of the plate. If the seams appear to have been leaking, they should be calked with a round-nose tool, Fig. 9. The calking should be done while the pressure is off or very low. If on testing after calking it is found that the leak cannot be stopped, some of the rivets may have to be replaced. If it is a lap-riveted, longitudinal seam the leak may be caused by a lap crack and the inspector should be called in to examine it. Although reriveting may be done by the engineer, it is best to call in a boiler maker. Should the shell over the fire become bagged and require a patch, the job should be turned over to a boiler maker. If the bag is not bad enough to need a patch, it may be driven up by heating it with a blow-torch, beginning at the outer edge and gradually driving it up. Have a template made of the radius of the outside of the shell as a gage.

Replacing Headers in Water-Tube Boilers

At the first glance this appears to be a hard proposition. Renewing a header in a Babcock and Wilcox boiler is no worse than renewing several tubes when they have to come out through the tube holes. These headers are cast steel and must be ordered from the factory, stat-



Tools for Removing Boiler Tubes

ing the number of tube holes and whether the header is for the front or back end. Sometimes the front headers become cracked at the lower end by the brick below the header falling out, exposing the end to the heat of the furnace, and as the pockets below the lower tube usually contain some scale, the header becomes overheated. A header may be ruined by having a piece cut out of the tube seat in ripping out an old tube.

In one instance five headers were cracked on the front end and two on the back end, when the blowoff pipe pulled out of the flange fitting, draining the boiler and causing the tubes to overheat. The feed water was on at the time and as this came in contact with the overheated headers they cracked.

To replace these headers an assortment of special tools is required. As the tubes are usually in good condition, except possibly the bottom one, the header is split off the tubes. This is done by a block made to fit the tube cap-hole and split in half, having a taper slot and wedge as shown in Fig. 10. The tube cap-hole is nicked with a chisel at the top and bottom and will usually split from one hole to the next. This leaves the tubes in good order but with the ends expanded. The nipple connecting the top end of the header to the steam drum is then split with the ripper, closed up and then pulled out.

After the old header is removed the ends of the tubes are swedged down to the original size. They are heated in a charcoal furnace, Fig. 11, made of a short piece of 5-in. pipe having one end drawn down to $4\frac{1}{4}$ in. and the other capped. In the lower side of the cap is connected a 1-in. pipe 3 ft. long to act as a handle and to which the air pipe is connected. A hole in the top of the 5-in. pipe with a hinged cover admits fresh fuel. The air supply is taken from the air-compressor line or other source. A piece of firebrick is placed in the tube about a foot from the end and the heater slipped over the end of the tube. It will only take a few minutes to heat the tube to a bright red.

The swedge used to draw the end down should be made as shown in Fig. 12. This is turned out of a solid piece of machinery steel. The bore is tapered from $4\frac{3}{8}$ in. at the mouth to 4 in. at the end of the taper, and straight from there to the bottom. This is driven on the hot tube with a sledge and if driven quickly only one heat will be necessary. To prevent the rear end from being loosened while swedging, block it by bracing to the wall or a solid part of the boiler. After the tube ends are drawn down, all the tube and nipple holes are cleaned out in the new header and it is slipped onto the ends of the tubes, which will have to be raised up and entered with a bar. Two pieces of wood 2x4 in. and about three feet long are made with holes bored to slip over the stud of the tube-hole caps, one in the new header and one on each of the old ones on each side, top and bottom. This brings the header up to place and square with the tubes. Care must be taken to get the header exactly in line, because if this is not done, much trouble may be given in putting in new tubes at any future time; they will bind on the adjacent tubes and will not go through the baffle-walls if the header is crooked.

After the header is in place and properly squared up with the tubes, the nipple holes should be lined up with the throat piece, and also with the mud-drum end if it is a rear header. Sometimes, with these holes in line, the tubes do not sufficiently extend through the holes to allow them to be belled. The cause may be that the header on the opposite end has been pushed out in swedging the tubes and can be sprung back. If this cannot be done, it will be necessary to push the header on farther and roll the nipples in at a slight angle. Cut the nipples from a piece of new tube and expand them in place with the adjustable expander, using the jointed plug shown in Fig. 4. The top end should be expanded first. The bottom end of the top nipple may be rolled through the top tube-cap hole with the jointed plug. In rolling the mud-drum end of the bottom nipples with the loose collar of the adjustable expander reversed to increase the distance between the collar and the rolls, taper rolls are used instead of straight ones. The plug is entered through the lower tube-cap hole. This will bell the projecting end of the nipple. Before expanding the nipple in the header make sure that it is square with the tubes, especially if it is on the front end.

After the work is completed a hydrostatic test of one and one-half times the working pressure should be given. Some of the joints on the opposite end from the new header may show signs of leakage and will have to be re-expanded. This work of replacing headers may be done under the supervision of the engineer

New Traveling Screens at Delray

By C. F. Hirshfeld*

SYNOPSIS—Endless screens specially designed to simplify the washing operation. If desired they may be washed continuously while in operation.

An interesting installation of traveling screens for screening the circulating water has just been completed at the Delray plant of the Edison Illuminating Co., of Detroit. This plant contains eight vertical-type Curtis turbines with an aggregate rated capacity of around 93,000 kw. The circulating pumps which serve the condensers of these units have an aggregate capacity of about 173,000 gal. per min.

This large quantity of water is drawn from the Detroit River, on the bank of which the plant is built. After flowing through the condensers it is returned to the river at a point farther down stream. At all times of the year the water is apt to contain large quantities of floating and submerged débris of one sort or another, and in the fall of the year it generally carries large quantities of grass and other marine growths which have broken loose from the flats at the lower end of Lake St. Clair and at the entrance to the river. At certain periods large quantities of fish of various sizes also appear at the plant.

To prevent the clogging of pump runners and of condenser tubes, it is therefore necessary to screen the water thoroughly before it is circulated through the plant. Before the installation of the traveling screens this was done by passing the water first through gratings or trash racks and then through vertical screens. A so called screen house is located at the plant end of the intake canal. The water flows through arches under one wall of this house and then through the gratings, which give it a rough screening. These gratings are about 6 ft. in width and

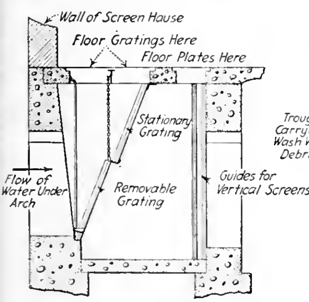


Fig. 1. Arrangement of Screens

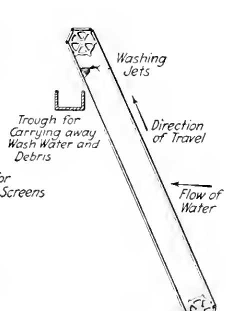


Fig. 2. Endless-Belt Screen

a little over 7 ft. in length. They are made of 3/8x3-in. flat iron bolted together with broad sides adjacent and with 3/4-in. spaces between neighboring bars. They are set with the edges of the bars toward the current and at an angle as shown in Fig. 1, two gratings being joined end to end to give a total length, or height on the incline, of about 14 1/2 ft. There are twelve of these units arranged along the length of the screen house. Removable gratings in the floor above facilitate inspection and cleaning.

After passing through the gratings the water strikes the vertical screens. These consist of copper-wire screen fastened upon a rectangular frame made of channel and angle irons. The frames are about 9 ft. wide by about 12 ft. high and are divided into four rectangular panels

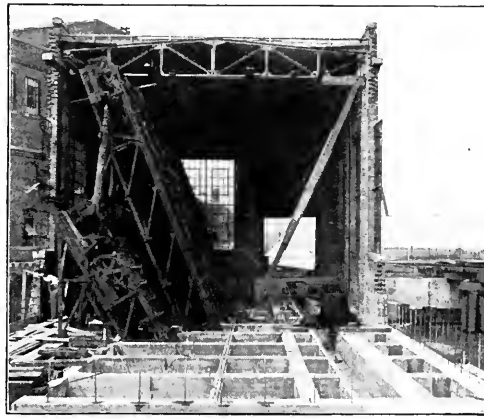


Fig. 3. Screen House Partly Completed

by horizontal and vertical cross-members. Each panel is braced by two diagonals. This construction affords a stiff frame and does not give large unsupported areas of screen. The wire screen is so woven that the mesh is rectangular and the openings measure approximately 1/4 in. in each direction.

These screens are arranged in units of two each. The back of one screen of a unit is placed adjacent to the face of the other screen of that unit, thus making the water flow through the two in series. The two screens of a unit are dropped into vertical channels which serve as guides and support them in a vertical position with their lower edges resting on the bottom of the water way. This arrangement makes possible the raising of one screen of a unit for washing without entailing the closing of gates or the passing of unscreened water. There are six of these units distributed along the length of the screen house on a line parallel to that of the gratings already described.

In ordinary operation all of the screens were washed three times per day, but when the water contained large quantities of marine growths it was often necessary to wash screens continuously, and even then the water in the rear of the screens frequently fell to an alarming extent.

When a screen is to be washed, the checkered iron floor-plates above it are first raised and moved out of the way by a small hand-operated winch carried on a car rolling on a track laid in the screen-house floor. One screen is then raised by means of a traveling crane and placed in

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a wash box, which is mounted on wheels and travels along the rails just mentioned. This box is open on the side opposite the rear of the screen when in position, and the screen is washed by means of a fire hose and nozzle which plays the water against the rear of the screen, thus driving out all débris which has been caught in the mesh and forcing all accumulations off of the face or front side of the screen. The wash water, with its burden of trash, flows to waste through a spout fastened to the bottom of the wash box.

The new screens were designed to simplify the washing operation. They can be washed continuously while in operation, if desired. Each unit consists of an endless belt carried over sprocket wheels at the top and bottom of a frame, as shown in Fig. 2. The belts are made of panels formed of a light frame and wire screen similar to that used on the older screens.

The belt can be moved by means of a geared motor in the direction indicated in Fig. 2, the speed being 12 ft. per min. The débris collected on the face of the belt can thus be carried up over the top and down the back and washed off into a trough, as shown in the drawing.

For ordinary water conditions, the screens stand stationary most of the time, each screen being moved and washed once in four or five hours. In case of very bad water, it is, however, possible to wash all screens continuously, thus precluding the possibility of getting low water in the plant because of fouled screens.

Seven of these screens have been installed in a new screen house located over an enlargement in the old intake canal, and there is room for the installation of three more. Each frame with its motor and screen belt forms a unit and is located in a separate compartment or canal between concrete walls. These walls carry inclined guides on which the frame of the unit is supported and on which it can be slid upward and out of the water for inspection, painting or repairs. The passing of unscreened water when a unit is raised is prevented by closing a gate at the entrance to the canal or passage in which that unit is housed.

The screen house is shown partly completed in Fig. 3, with one screen lowered into place and the rest raised in the position they would occupy when being inspected or repaired. The circulating water flows from under the trestle at the right, through the screens, and into the old screen house, which can be seen to the left. The interior of the completed screen house is shown in Fig. 4, with seven screens in operating position.

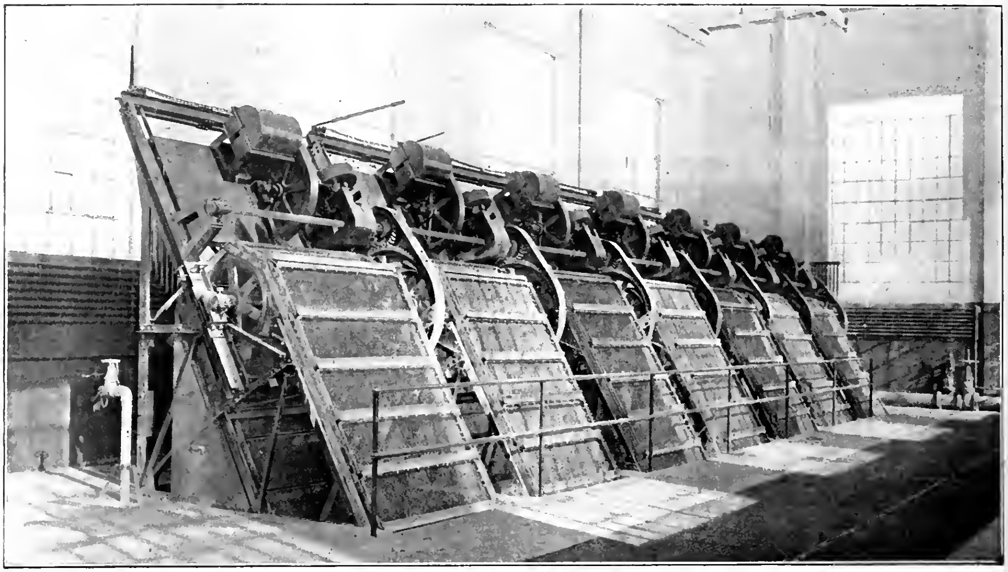


Fig. 4. Several Units in Operating Position

Gripwell Pulley Covering

Gripwell pulley covering is a cement to be used on the face of pulleys to prevent the slipping of the belt and to permit of running it loose. It is applied to the pulley, which has been cleaned with a strong solution of sal soda dissolved in water to remove all grease, etc., in a thin coat with a brush and is then allowed to stand until hard and dry.

In the case of large belts a covering of canvas ¼ in. narrower than the face of the pulley is applied to the latter about twelve inches at a time, and rubbed down hard with the cement until the pulley is covered.

It is claimed for this covering that it prolongs the life of the belt, the bearings and the machinery, that it eliminates the taking up of belts and is waterproof.

This pulley covering is manufactured by the Gripwell Pulley Covering Co., Hollis, L. I., N. Y.

Tantalum is much harder than diamond, as is shown by the fact that the only effect produced by a diamond drill, worked day and night for three days on a sheet of metal 1/25 in. thick, with a speed of 5000 r.p.m., was a slight dent in the sheet and the wearing out of the diamond. When red hot, tantalum can be easily drawn into wire or rolled into sheets.

Direct-Current Armature Winding Principles

By Jacob Gintz, Jr.

SYNOPSIS—Directions for the proper spacing and connecting of coils in both series and parallel windings.

The principle of armature winding is nothing more than placing a number of coils, properly spaced and connected to the commutator, so that they accumulate the induced electromotive force produced in the various coils which are connected in series between the brushes.

There are two types of direct-current windings—lap, or parallel, and series, or wave, windings. These are again divided into classes according to the number of winding elements per slot; that is, if a winding has one element per slot it is called a "one-layer winding," and if it has two elements per slot it is called a "two-layer winding." Two winding elements form one complete coil, and the distance that these two elements are apart depends upon the number of coils and poles and is expressed in the number of winding spaces.

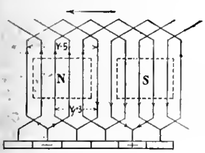


Fig. 1. Front Pitch Less than Back Pitch

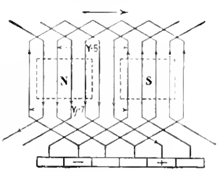


Fig. 2. Front Pitch Greater than Back Pitch

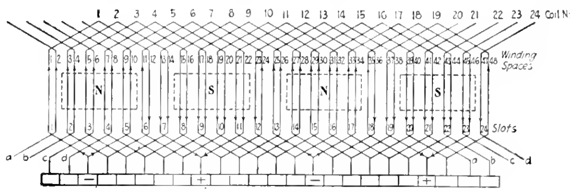


Fig. 3. Winding Laid Out in Accordance with Data in Table 1

When an armature is being prepared for winding, the first step is to insulate the slots, the ends of the core, the shaft and any other parts of the metal with which the winding may come in contact. The materials used for this purpose are fiber paper, shellacked canvas or muslin on the smaller armatures, and on the larger ones, micanite, press-board, empire cloth and various other materials. The coil must be so placed that both its elements do not come under the influence of the same field polarity at the same time, that is, while one side of the coil is influenced by a north pole the other side must be influenced by a south pole. The distance between opposite sides of the same coil is called the pitch, or spread, and is found by the formula

$$\frac{C \pm A}{P} = Y$$

in which C is the number of coils to be placed on the armature, A the number of times the current divides at the negative brushes (once at each negative brush), P the pairs of poles and Y the spread of the coil, expressed in the number of winding spaces. The value of Y must be an odd number. Should it result in an even number, it must be made odd by adding one. If it results in a mixed number, drop the fraction, and if the remaining whole number is odd the value of Y will be the same, even if it is made odd as explained above. This applies to lap, or parallel, windings only.

When the spread of a coil has been found, the distance from the end of one coil to the beginning of another is

$$Y \pm 2 = Y_f$$

where Y is the spread of the coil, counted across the back end of the armature (the end away from the commutator) and Y_f the front pitch, also expressed in the number of winding spaces, but counted across the front end of the armature. The pitch Y_f, however, is not a winding pitch, but merely the distance from the end of one coil to the beginning of the next. In many cases it has been found that instead of considering the pitch Y_f, it is easier for the winder to know that the winding is to be placed from right to left or from left to right and that the beginning of the second coil is to be two winding spaces from the first.

There is an advantage when using —2, in that the ends of a coil do not cross one another in connecting to the commutator, thus obviating the danger of short-circuit. When +2 is used the leads will cross as shown in Fig. 2.

In Fig. 1, $Y = 5$ and $Y_f = 3$

In Fig. 2, $Y = 5$ and $Y_f = 7$

If the connections in Figs. 1 and 2 are applied to two armatures and both are run in the same frame, that in Fig. 1 will run in one direction and that in Fig. 2 in the opposite direction.

In lap, or parallel, windings there will be as many brushes set around the commutator as there are poles in the machine. If such a winding is run with less brushes than poles the entire winding will not be active, and in the case of small machines sparking at the brushes would strongly interfere with operation.

For a practical example of a lap, or parallel, winding consider an armature having 24 slots and 24 coils to be placed in a four-pole machine.

In the winding where there is a like number of coils and slots (each coil being represented by two winding elements) there will be two winding elements per slot, and it will be termed a two-layer winding. There will also be 24 commutator bars, since there must be as many bars as active coils. In a four-pole machine the coils must spread at least one-quarter of the circumference, or 180 electrical degrees. Now find the spread or pitch expressed in the number of winding spaces, with $C = 24$ and $A = 2$. In lap- or parallel-wound armatures there are as many brushes as poles; then two brushes will be negative and two positive, and as the current will divide once at each negative brush, there will be two divisions of current. Also $P = 2$, since there are 4 poles (one north and one south pole make one pair). Applying the formula;

$$\frac{C + A}{P} = Y, \text{ or } \frac{24 \pm 2}{2} = \frac{26 \text{ or } 22}{2} = 13 \text{ or } 11$$

While it is possible to use either 13 or 11 winding spaces, one spacing having no electrical advantage over the other, it is better to use the smaller value, because it requires less wire to wind the armature, saving material and cost of manufacture.

Having chosen 11 winding spaces for the spread of the coil, then the first coil will be placed in winding spaces Nos. 1 and 12 (11 spaces between). This being a two-layer winding, space No. 1 will be in slot No. 1 and space No. 12 will be in slot No. 6. To locate the beginning of coil No. 2, apply the formula, $Y \pm 2 = Yf$. This will give the number of winding spaces to be counted back from the end of coil No. 1 to the beginning of coil No. 2. Remembering the advantage and disadvantage of the minus and plus values of 2 in this formula, then, $Y \pm 2 = Yf$, or $11 \pm 2 = 13$ or 9. Taking the minus value of Y_f, which is 9, and counting 9 winding spaces back from No. 12 will bring the beginning of coil No. 2 in winding space No. 3, in slot No. 2. Then, spreading the second coil 11 winding spaces between Nos. 3 and 14 will bring it in slots Nos. 2 and 7. Table 1 indicates the number of the winding space and the number of the slot between which the coils are wound.

TABLE 1

Coil No.	Spaces No.	Slots No.	Coil No.	Spaces No.	Slots No.
1	1 and 12	1 and 6	13	25 and 36	13 and 18
2	3 and 14	2 and 7	14	27 and 38	14 and 19
3	5 and 16	3 and 8	15	29 and 40	15 and 20
4	7 and 18	4 and 9	16	31 and 42	16 and 21
5	9 and 20	5 and 10	17	33 and 44	17 and 22
6	11 and 22	6 and 11	18	35 and 46	18 and 23
7	13 and 24	7 and 12	19	37 and 48	19 and 24
8	15 and 26	8 and 13	20	39 and 2	20 and 1
9	17 and 28	9 and 14	21	41 and 4	21 and 2
10	19 and 30	10 and 15	22	43 and 6	22 and 3
11	21 and 32	11 and 16	23	45 and 8	23 and 4
12	23 and 34	12 and 17	24	47 and 10	24 and 5

TABLE 2

Coil No.	Spaces No.	Slots No.	Coil No.	Spaces No.	Slots No.
1	1 and 8	1 and 4	9	17 and 24	9 and 12
2	3 and 10	2 and 5	10	19 and 26	10 and 13
3	5 and 12	3 and 6	11	21 and 28	11 and 14
4	7 and 14	4 and 7	12	23 and 30	12 and 15
5	9 and 16	5 and 8	13	25 and 2	13 and 1
6	11 and 18	6 and 9	14	27 and 4	14 and 2
7	13 and 20	7 and 10	15	29 and 6	15 and 3
8	15 and 22	8 and 11			

By following this table Fig. 3 is constructed. The spacing of brushes, expressed in the number of commutator bars from the toe of one brush to the toe of the next of opposite polarity, is determined by dividing the number of commutator bars by the number of poles. In Fig. 3, 24 bars ÷ 4 poles = 6 bars from one brush to the other.

In connecting the windings to the commutator one should know how the brushes will be set in relation to the polepieces. If they are to be set as in Fig. 4, the beginning of each coil should be connected straight out from the slot to the commutator bar, or if they are set as in Fig. 5, the beginning of each coil will be connected a certain number of commutator bars to the right (in parallel windings only), this number of bars, known as the "lead pitch," being determined by dividing the number of commutator bars by twice the number of poles. If this results in a mixed number it should be increased to the next whole number. The reason for these connections is that when the coils are under commutation they should be in neutral position.

When coil AB, Fig. 4, has moved to the position $A'B'$, its conductors are moving parallel with and are not cutting the lines of force; hence, they will not produce an electromotive force. At the same time the commutator bars, to which the coil leads are connected, are under the brushes C. If the coils were connected as in Fig. 5 with the brushes set as in Fig. 4, it would be impossible to operate the machine, because there would then be a dead short-circuit of the coil whose bars were under the brushes.

In some types of armatures there are two or three times as many commutator bars as there are slots in the armature core, the coils being wound with two or three wires in hand, which is the same as winding so many individual coils and connecting them together as one. There are two methods of connecting the coils to the commutator, namely, in parallel or individually. When two or more coils are connected in parallel it is to do away with the handling of large conductors and to make it easier to wind and shape the coils; in this case there

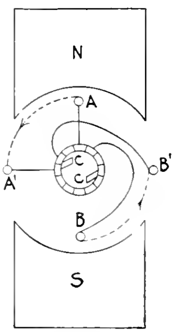


Fig. 4

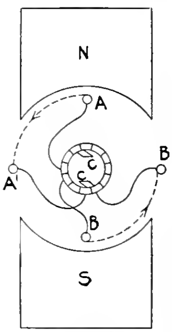


Fig. 5

Winding Dependent on Setting of Brushes

will be as many commutator bars as there are slots. When there are two or three times as many commutator bars all the coils will be connected separately. This is done to keep the potential between the bars down to a minimum; that is, about 5 volts between bars of machines not exceeding 110 volts, 10 volts between bars of machines not exceeding 220 volts, 15 volts between bars of machines not exceeding 550 volts, etc. These differences in potential apply to both series- and parallel-wound armatures.

The series-wound armature is little different from the parallel-wound armature except in the connections between the coils and the commutator bars.

A wave, or series, winding is sometimes called a two-circuit winding, because it requires but two brushes (one pair) and, as previously explained, there is but one division of current for each negative brush, which is equal to two paths, or circuits. To find the spread, or pitch, of a coil in a series winding, apply the same rule as in the parallel winding, but the value of Y can be any number —odd, even, or a mixed number. Series windings are divided into two classes, namely, single- and average-step windings, depending on the value of Y. If Y is an odd number the winding will be single-step, in which case Y will equal the commutator pitch (the distance between opposite ends of the same coil expressed in the number of commutator bars). When Y is even it must be made odd by adding one, but the commutator pitch can have two values, that is, it can have the original value of Y or it can equal the coil pitch, which was made an odd number, as explained; this is termed average-step winding. The two values of the commutator pitch are called the "long" and the "short" pitch. The short pitch is preferable because it results in fewer crossings of leads from the coils to the commutator. Fig. 6 illustrates the use of the short pitch in a four-pole series winding, showing two coils in series between adjacent commutator bars from right to left, and Fig. 7 shows the long pitch with two coils in series between adjacent bars from left to right.

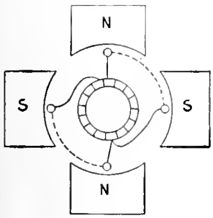


FIG. 6. ILLUSTRATING THE SHORT PITCH

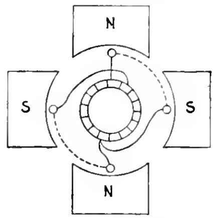


FIG. 7. ILLUSTRATING THE LONG PITCH

If a series-wound armature has been connected according to the short pitch and is reconnected with the long pitch, it will reverse the direction of rotation of the armature.

If the value of Y should result in a mixed number the fraction is dropped. In a four-pole winding this can only be ½; in a six-pole winding ⅓, etc. By dropping the fraction there will be an inactive coil, that is, one which will not be connected to the commutator. This, however, will occur only in the older types of armatures, for in the modern designs this has been eliminated, there being an odd number of coils in the winding. In any two-circuit winding it is impossible to connect an even number of coils.

For a practical example of a wave-, or series-wound armature, consider one having 15 slots and 15 coils to be placed in a four-pole machine. This will be a two-layer winding, since there are as many coils as slots, and 15 commutator bars will be required. Then $C = 15$, $P = 2$, and $A = 1$, since only one pair of brushes is required and there will be but one division of current.
Then

$$\frac{C \pm A}{2} = Y, \text{ or } \frac{15 \pm 1}{2} = 8 \text{ or } 7$$

Using the minus value of A, as previously explained (in parallel windings), $Y = 7$. Referring to Fig. 8, this will spread coil No. 1 between winding spaces 1 and 8 (which is seven spaces from No. 1) and it will be located in slots 1 and 4. To find the position of coil No. 2, apply the formula $Y \pm 2 = Yf$. Using the minus value of 2, as explained for parallel windings, $Yf = 5$. Counting 5 winding spaces back from No. 8 will bring the beginning of coil No. 2 in winding space 3 in slot No. 2. Then spread coil No. 2 from space 3 to 10 in slots 2 and 5. Table 2 indicates the number of the winding space and the slots between which the coils will be wound.

The connections between the coils and the commutator are made according to the commutator pitch, which in this problem can be either 7 or 8, as previously explained.

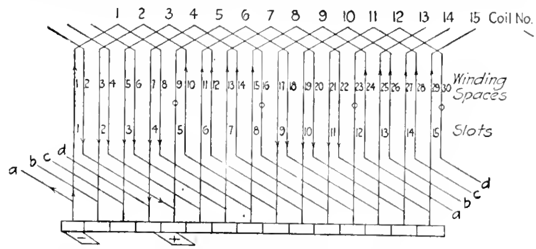


FIG. 8. WAVE WINDING BASED UPON DATA IN TABLE 2

Using the short pitch 7, the coils will be connected as indicated in Table 3.

The spacing of the brushes in Fig. 8 is found by dividing the number of commutator bars by the number of poles; that is, 15 ÷ 4 = 3¾ bars. By placing a negative brush on bar 1 and a positive brush 3¾ bars away, which will be between bars 4 and 5, the direction of current through the winding will be as indicated by the arrows. If the windings in Fig. 8 were connected according to the long pitch, the connections would be made as indicated in Table 4.

TABLE 3

Beginning of coil No. 1 to bar No. 1	End of same to bar No. 8
Beginning of coil No. 2 to bar No. 2	End of same to bar No. 9
Beginning of coil No. 3 to bar No. 3	End of same to bar No. 10
Beginning of coil No. 4 to bar No. 4	End of same to bar No. 11
Beginning of coil No. 5 to bar No. 5	End of same to bar No. 12
Beginning of coil No. 6 to bar No. 6	End of same to bar No. 13
Beginning of coil No. 7 to bar No. 7	End of same to bar No. 14
Beginning of coil No. 8 to bar No. 8	End of same to bar No. 15
Beginning of coil No. 9 to bar No. 9	End of same to bar No. 1
Beginning of coil No. 10 to bar No. 10	End of same to bar No. 2
Beginning of coil No. 11 to bar No. 11	End of same to bar No. 3
Beginning of coil No. 12 to bar No. 12	End of same to bar No. 4
Beginning of coil No. 13 to bar No. 13	End of same to bar No. 5
Beginning of coil No. 14 to bar No. 14	End of same to bar No. 6
Beginning of coil No. 15 to bar No. 15	End of same to bar No. 7

TABLE 4

Beginning of coil No. 1 to bar No. 1	End of same to bar No. 9
Beginning of coil No. 2 to bar No. 2	End of same to bar No. 10
Beginning of coil No. 3 to bar No. 3	End of same to bar No. 11
Beginning of coil No. 4 to bar No. 4	End of same to bar No. 12
Beginning of coil No. 5 to bar No. 5	End of same to bar No. 13
Beginning of coil No. 6 to bar No. 6	End of same to bar No. 14
Beginning of coil No. 7 to bar No. 7	End of same to bar No. 15
Beginning of coil No. 8 to bar No. 8	End of same to bar No. 1
Beginning of coil No. 9 to bar No. 9	End of same to bar No. 2
Beginning of coil No. 10 to bar No. 10	End of same to bar No. 3
Beginning of coil No. 11 to bar No. 11	End of same to bar No. 4
Beginning of coil No. 12 to bar No. 12	End of same to bar No. 5
Beginning of coil No. 13 to bar No. 13	Ene of same to bar No. 6
Beginning of coil No. 14 to bar No. 14	End of same to bar No. 7
Beginning of coil No. 15 to bar No. 15	End of same to bar No. 8

The brushes being set in the same position, the current will be reversed, which would also reverse the direction of rotation of the armature.

If the brushes were set as in Fig. 4, in relation to the poles, the beginning of each coil would be connected straight out from the slot to the commutator bar, and if they were set as in Fig. 5, the beginning of each coil would be swung a certain number of bars to the left (in series windings only), this number being found by dividing the number of commutator bars by twice the number of poles.

In Fig. 8 the positive brushes are set across bars 4 and 5, and as there are as many coils in series between adjacent bars as there are pairs of poles, there will be two coils in series. Therefore, there will be two coils short-circuited—Nos. 5 and 12, which are marked with small circles.

The formulas employed in this article are somewhat different from those found in textbooks, but they arrive at the same results. A winder will always remember that the winding step Y must be an odd number, and that the difference between any two adjacent coils must be two winding spaces; also, before connecting the winding to the commutator he will find out in which position the brushes are going to be set. This will apply to both series and parallel windings.

Test of Booster Pumps

At the Roseland Pumping Station, Chicago, two booster pumps were recently installed to raise the pressure of 50 to 60 lb., normally carried in the water main, to a maximum of 87 lb. (200 ft.) for the Washington Heights section.

Each unit, as shown in Fig. 1, consists of a 14-in. Worthington horizontal centrifugal pump direct-connected to a 115-hp. Kerr turbine running at 2750 r.p.m., a 325-sq.ft. Worthington cylindrical shell waterworks type surface condenser located in the suction next to the pump, a 5x12x10-in. single vertical flywheel-type air pump with attached hotwell pump, and a 4-in. automatic atmospheric-exhaust valve. The main pumps are of the single-stage, double-suction, screw impeller type with volute casings, and the turbines are each controlled by two governors—a speed-regulating governor and a pressure-regulating governor. The former is of the oil-relay type and the latter of the Fisher type, designed to maintain a constant pressure in the mains regardless of any fluctuations in either the capacity or the suction pressure.

Some of the principal dimensions are as follows: Suction inlet of pump, 13 in. square; discharge outlet, 14 in. diameter (corresponding to a velocity of $7\frac{1}{4}$ ft. per sec.); steam inlet to turbine, $2\frac{1}{2}$ in.; exhaust outlet, 12 in.; condenser water outlet, 13 in. square, and water inlet, 20 in. diameter. A steam pressure of 170 lb. gage is carried. The manufacturers guaranteed that each pumping unit would develop a duty of not less than 67,000,000 ft.-lb. per thousand pounds of steam at the pressure stated, and not less than 98 per cent. quality when delivering at the rate of 5,000,000 gal. of water per 24 hr. against a head of 85 ft. (not including friction through the pump nor through the suction and discharge piping as measured between the suction- and discharge-pressure gages).

The acceptance tests were conducted by a board of three engineers—one representing the City of Chicago, one the contractor, and the third selected by the first two. In order to vary the capacity and maintain the same constant during each run, the discharge piping system was isolated from the Washington Heights high-pressure system and the water returned to the low-pressure system through cross-over valves controlling the rate of flow. A pitometer was installed about one mile west of the station at a point convenient to the valves mentioned, which were manipulated as necessary to get the desired rate of flow as indicated by the pitometer. This method of regulation permitted constant rates of flow to be maintained, and the temporary isolation of the discharge from the service lines gave the desired freedom from surges which would otherwise have been present in the mains.

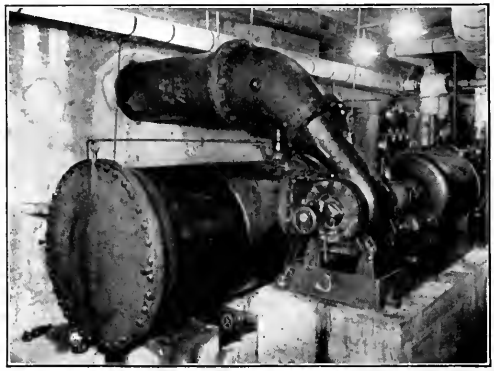


FIG. 1. ONE OF THE BOOSTER UNITS

In accordance with the specifications, the quantity of water pumped during the tests was measured by a 30-in. venturi meter, which is a part of the permanent equipment of the pumping station. The air pump was operated condensing, and the condensate from it was weighed along with the condensate from the main turbine.

The curves in Fig. 2 show the relation between head, capacity and duty through the range covered by the tests, the dotted lines showing the probable performance beyond this range.

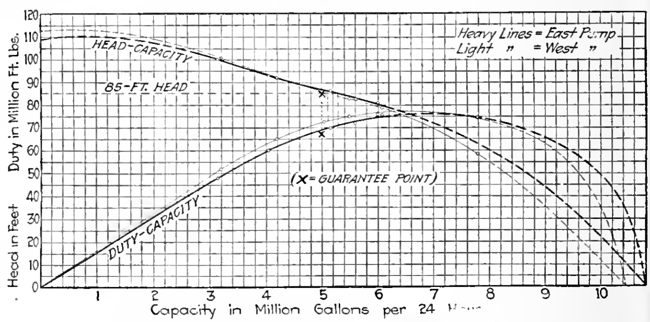


FIG. 2. CURVES SHOWING PERFORMANCE OF PUMPS

The west pump showed a duty of 73,000,000 ft.-lb. per 1000 lb. of steam, corrected to an initial pressure of 170 lb. gage and 98 per cent. dry, and a capacity of 5,120,000 gal. per 24 hr., thereby exceeding the guaranteed performance by 8.95 per cent. in duty and 2.4 per cent. in capacity.

The tests of the east pump, when operating against the specified head at 85 ft., showed an initial duty of 71,000,000 ft.-lb. per 1000 lb. of steam, corrected to the initial conditions, and a capacity of 5,280,000 per 24 hr., thereby exceeding the guaranteed performance by 5.97 per cent. in duty and 5.6 per cent. in capacity.

Editorials

Research and Equipment Engineering

Few engineers are privileged to keep in touch with the progress of laboratory and mathematical investigations in different parts of the world, which affect power-plant development and operation in indirect ways. The reasons are that intense absorption in "practical" problems takes so much time and that research work is conducted for long periods with little publicity because the follower of pure science hesitates to give out results not well established. It is a great mistake, however, to look upon research as a subject of mainly speculative interest, for out of experiments and studies often far removed from matters of routine operation sometimes come developments of immense engineering value.

In a lecture given recently at the Worcester (Mass.) Polytechnic Institute, Professor Albert Kingsbury, inventor of the thrust bearing associated with his name, outlined the steps in lubrication research, extending over many years, which led to the final development of this interesting equipment. Without recounting the sequence of events, it is of interest to note that the most delicate resources of the physical laboratory were drawn upon in measuring the axial eccentricity of a revolving piston fitting closely in a cylinder in which the only lubrication was provided by a film of air about one-thousandth of an inch thick; in studying the wedge effect of rotation upon the lubricant, and in comparing experimental observations with the predictions of Reynolds, whose remarkable mathematical studies of bearing friction, published in the "Transactions of the Philosophical Society of Great Britain" as far back as 1886, threw a flood of light upon many phenomena of obscure explanation noted in the subsequent tests.

The dependence of bearing friction upon speed rather than upon load under these conditions, the practicability of measuring pressure distribution at different points on bearings by multiple gages of the mercury type, the checking of piston displacement by a telephone receiver, setscrew, battery and contact method, taking advantage of the excellent insulation provided by the minute skin of air between the piston and the cylinder, and the study of tool-point lubrication by microscopic observation of cuts in a running lathe, all had a bearing upon the investigation which need not be detailed here, but they serve to point out that it is rash to limit the possibilities of scientific method or to take it for granted that because a phenomenon in friction, thermodynamics or electricity is obscure, it is beyond the reach of modern laboratory apparatus. Few of us need to master the detailed calculations of Reynolds, Lord Kelvin and other savants in the field of mechanical friction, but it is singular and interesting that the experimental results of Kingsbury were so accurately forecasted by mathematical research, which, however, in the case of Reynolds, made the mistake of supposing that the minute quantities involved could not be experimentally measured.

Each type of investigation thus supplemented the other, and the two together ultimately brought forth a useful form of equipment for commercial service, in which the principles determined in investigations which might seem largely theoretical were turned to account in the design and construction of apparatus for power-plant applications. In a broad sense, the final research was a byproduct of a study of the friction of screws—a point worth bearing in mind in observing and recording collateral phenomena in connection with any technical investigation.

A Suggested Activity for the Engineering Foundation

Few realize the prodigious rate at which additions are being made to available engineering information. In the first place, there are constantly appearing new branches and ramifications to engineering. A half-century has developed electricity into a great industry with an extensive literature, abstract and applied. In a quarter of a century the internal-combustion engine has grown from a driver of coffee mills to one of rolling mills. A couple of decades has seen the evolution of the steam turbine with all the consequent changes in power-plant apparatus and design.

These in our own field; in other fields as great or greater developments have taken place. And with all this, in addition to the fund of knowledge which we have acquired and are still acquiring about the old things, come voluminous contributions to current knowledge about the new. Research laboratories are discovering; committees are investigating and reporting; professors and postgraduates are studying; inventors and developers and manufacturers and users are finding out; professional societies are hunting all who have special information and inducing them to add it to the general fund. The technical press has, for its reason for being, the production and recording of such information. The specialist who a few years ago could get all the available information about his subject in a few standard volumes, the proceedings of a single society, and perhaps a monthly magazine, could now keep so busy reading about it that he would have no time to practice.

In the mass of engineering literature produced, transient as may be the interest of much, subject to criticism and refutation as may be a great deal, duplicative and even contradictory as may be some, there are recorded the accumulated knowledge of and thought upon the subject. If out of this, the material of permanent interest could be put upon record in an orderly fashion, so that the seeker for knowledge upon a particular phase of any engineering subject could find it all together, what effort and time and money would be saved to the delver for facts already known and the traveler upon paths which have been already demonstrated to lead into a dead end.

To what worthier purpose could the trustees of the Engineering Foundation so generously established by Ambrose Swasey devote their initial activities than to the development of some method of analyzing, classifying and filing engineering information? With sufficient time and talent, a system could be evolved under which the periodicals could print against the titles of articles of reference value or even against individual paragraphs, numbers, of the Dewey-decimal or other system, which would automatically lead these articles or card-index references to them into the right file. The principal reason that this has not been already done is the want of a standard filing system for engineering information.

This is the one engineering purpose in sight which is broad enough to warrant the use of a fund designed "for the advancement of engineering art and sciences in all their branches, to the greatest good of the engineering profession and to the benefit of mankind." And the motion by Henry Hess, in his discussion of the paper by Edwin J. Prindle, dealing with the classifying and indexing of the records of the American Society of Mechanical Engineers, to the effect that it be suggested as an object of their interest and activity, should have been sustained.

One might as well not have a thing as to have it and not know that he has it.

What better use could the means available be put to than in taking stock of current engineering knowledge, classifying and arranging it for ready reference, and organizing a system whereby new information would flow to its appointed place as it develops?

Analyzing Station Design

The study of generating plant and substation designs is instructive to any engineer. Even if an operating man never expects to lay out a plant it pays him to scrutinize the arrangement and composition of other installations than his own, for it gives him a broader outlook upon local problems and a sense of proportion which is a valuable asset. The more plants one visits, or studies through carefully prepared descriptions in the technical press and in the transactions of engineering societies, the more apparent it becomes that standardization in design is a long way off, and fortunately so. Nearly every installation has some peculiar feature of note, and it is always interesting to weigh and compare the merits of different ones.

A plant recently examined illustrates these points. Situated in a deep valley above a small town, the station is close to the edge of a cliff and utilizes a head of one-hundred feet, with a maximum development of about thirteen thousand horsepower in three direct-connected generating units of modern design supplied with water by a pair of large penstocks leading to the wheels from a dam a short distance above the station. The plant represents a gradual development which has been carried on by its owners with great skill in view of the local difficulties encountered. No criticism of these men is intended in the following comments upon the layout in relation to the latest ideas in hydro-electric development, which are simply advanced to show the importance of viewing installations from the standpoint of trying to see wherein they might be more efficiently arranged were the opportunity to build anew afforded. In other words, it is important to try to determine for oneself whether each installation visited measures up to the most advanced practice known to the visitor, and if not, to quietly study wherein it appears to fall short. This does not mean any failure to appreciate the good points of any layout or to condemn a plant for a few apparent defects for which its present owners and even its original designers may not be responsible, for the art of station design advances as do other affairs, and the best of today soon becomes eclipsed by the practice of tomorrow.

In the case selected, there are industrial plants on the river in the town which utilize eighty feet of additional fall in scattered wheels with both mechanical and electric drives. If the development were to be made today, the existing hydro-electric plant would not be built, but instead, a tunnel would be driven through the hill on one side of the town to the river over one hundred and eighty feet below on the other side of the barrier, and the entire development would be on the basis of utilizing maximum head in concentrated generating units. This would be bold compared with the ideas of the builders of the existing station, but this is the day of bold conceptions in engineering.

Close scrutiny of the present plant indicates the desirability of building a straight operating room free from angles, so that the switchboard can be seen from all points; of bringing the water into the wheels in penstocks which do not obstruct the view in the operating room and the movement of a high-powered traveling crane from end to end; of placing the switchboard where the shortest possible cable runs from the generators will be required that are consistent with good visual control of main units; of providing ample space for oil switches in outgoing lines and straightway runs for high-tension wiring; of placing the chief engineer's office in a commanding position in relation to the operating room instead of in a distant wing of the building without visual connection to the latter; and of avoiding unnecessary complications in high-tension bus and switching arrangements for the sake of a flexibility in operation seldom required in actual service.

Bearing in mind that the design of any station upon which good engineering is expended is more or less of a compromise, it is none the less true that critical examination of such installations pays well for the time and trouble put upon the work, provided at every point effort is made to formulate constructive and not merely captious criticisms.

That our insistence upon the danger of the breathing head is warranted is again attested by another failure of this sort, this time of a bumped head on a Stirling boiler in New Bedford. Fortunately, the defect was discovered before an explosion or serious damage occurred.

At the recent investigation of the Public Service Commission of New York for the First District, Travis H. Whitney, secretary of the commission, testified that in the electric-light cases against the New York Edison Co., which have lasted over three years, fifty-two hearings have been held and over one thousand eight hundred pages of testimony taken. The case, he said, has been reopened, not at the instance of the complainant nor the company, but on the application of the Merchants' Association. The company, however, made no objection.

Which is very funny, inasmuch as the application of the Merchants' Association has all the earmarks of having been inspired by the company itself.

Correspondence

Using Graphite in Boilers*

Mr. Weaver's letter in the Jan. 26 issue on the use of graphite reminded me of my experience with it in two or three plants. One plant had three 100-hp. locomotive-type boilers which were heavily scaled. After washing, I put 10 lb. of graphite into each boiler and then fed ½ lb. every twenty-four hours. In three months our boilers were free from scale, and in less than eight months from the date of beginning the use of graphite we had saved about $80 on the coal bill.

It seems to me that engineers expect graphite to act too quickly. It should be remembered that the graphite must get between the scale and the boiler shell and work the scale off by mechanical means. By feeding the graphite in the manner mentioned, a total of 160 lb. of hard scale was removed from a boiler in less than 70 days.

G. A. Bennett.

Denver, Colo.

Mr. Weaver's experience with graphite as a scale remover coincides with mine. I find that graphite and a good mechanical tube cleaner go together. The graphite will soften and loosen the scale and make it easier for the mechanical cleaner to bring it down in either a water-tube or fire-tube boiler. If a boiler is badly scaled it is slow and hard work to get the scale off even after the graphite has loosened it, but the cleaner will break it up and quicken the process of removal.

A. A. Blanchard.

Oxford, N. J.

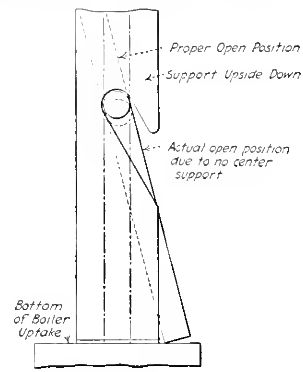
Dampers Would Not Close

The municipal water-works here has four vertical water-tube boilers of 450 hp. each. While the load seldom requires the operation of more than one boiler at a time, two are always under steam in order to provide service in case anything should happen to either boiler. This precaution is necessary, as the pumping engines operate on the Holly system without reservoirs.

During night loads it is advisable to bank one of the boilers. This had been tried on one pair of boilers with fair success. The other pair, however, could not be properly banked. Examination showed that the dampers stuck on the bottom while at the tops they were open as much as four inches. Each boiler has three damper paddles operated on one stem. At one time a strip had been cut from the bottom of a paddle to increase the clearance. This merely aggravated the trouble. Later the center paddle had been tied to the outer ones by straps which slightly bettered conditions.

As this failed to give satisfaction, further examination showed that the stem was bearing at the ends only, the center supports being over the notch for taking out the dampers, and apparently in upside down. The weight of the moving parts caused the damper to settle, strike the bottom first and prevent the top from closing. The more that was chipped off the bottom, the lower the damper sank. The result was inefficient operation when this bank of boilers was in use and a poorer draft when the other bank was on duty, as both are attached to the same stack.

The trouble was remedied by placing a small support under each of the centers between the paddles, thus keeping the bottoms free. The stack now has a much better chance to operate at full efficiency. How much coal went



Arrangement of the Damper

up the chimney since the boilers were installed is problematical. What we do know is that since April, when the station was taken over, the coal consumption has decreased 30 per cent. and the pumps run much slower, in spite of the fact that our meters are reporting more water consumed.

H. C. Wight.

Dayton, Ohio.

A Satisfactory Average Vacuum

In reviewing the many references to the effect of high vacuum on reciprocating engines which have appeared in a long series of volumes of Power, I have been impressed with the omission of consideration of the changeable temperature of condensing water throughout the year. Again and again the disadvantage of larger condensing apparatus, with its resulting high cost, is set down against the gain due to high vacuum, when any such gain is acknowledged at all. I have yet to see a single instance where the question is considered as to whether during the winter time (when high vacuum is available, inasmuch as cool entrance circulating water or injection water makes it so) it is desirable to have air-pumping apparatus of the requisite design and in a requisite state of maintenance, to make the potentially available high vacuum actually existent.

It is, of course, only in recent years that any serious opposition has appeared to the old view that 25 in. or

*See "Power," Jan. 6, Mar. 3 and 31, and Apr. 7, 1914.

slightly more represented the most economical vacuum for reciprocating-engine service—an argument apparently based on the widest experience in the days when it was customary for the hotwell water to be used as feed water without subsequent heating with the exhaust steam from independently driven auxiliaries. When this long accepted conclusion began to be questioned there remained a strange absence of any consideration of the possible desirability of keeping the condensing apparatus of moderate size, so that during summer weather only moderate vacuum could possibly be attained, but utilizing steadily increasing vacuum as condensing water becomes colder from summer to winter.

Utilization of this scheme necessitates air-removing apparatus of the best possible operating characteristics. But such apparatus is relatively inexpensive when it represents dry-vacuum pumps used with surface condensers and still less expensive when it represents mere modernized design of jet condensers of the barometric or equivalent form. Why has it not become recognized that a condensing-engine equipment is not installed, and should not be thought of as installed, to maintain some definite and constant vacuum throughout the year, whether it be 26 or 28 in. or more, but as installed is capable of maintaining a certain vacuum in summer and a much higher vacuum in winter, and is to be so operated throughout the year as to maintain as nearly as possible a constant vacuum efficiency referred to the changing vacuum available?

H. L. H. Smith.

Brooklyn, N. Y.

A Puzzling Ground

Several years ago, while operating a substation, I had a peculiar experience with a large booster set used for charging a storage battery and boosting one of the long feeders. The system was Edison three-wire with the neutral grounded; 230 volts across the outside wires and 115 volts to the neutral.

The switches on the high-tension side of the system were remote-controlled, and to operate these, as well as the protective devices on the different units a separate operating busbar was connected across the positive main busbar and the neutral. Fig. 1 shows the connections of the booster and operating busbar.

The first indications of trouble occurred one Sunday, when one of the attendants received a shock while cleaning the booster. Everything on the switchboard was apparently as it should be, so I touched the machine rather gingerly in several places, to see if I could repeat the performance, but without results. With a test lamp I then tested every conceivable place and finally went over the machine with the portable voltmeter, without finding anything wrong.

Everything went along all right for a couple of weeks, when, on Sunday, while making an insulation test the chief found the operating busbar grounded and told me to locate the trouble. To my surprise the operating busbar tested clear, whereupon I decided that the chief had been mistaken and told him so the next day. He maintained, however, that the busbar was grounded when he tested it.

Two days later the chief received a jolt from the commutator of the booster. He was too busy at the time to investigate, but instructed me to do so. Again everything tested clear, only to be followed by the night man receiving a shock from the same machine.

This was getting to be a joke, so I connected a lamp between the frame of the machine and a water pipe to make a ground and placed the lamp directly above the desk so that anyone would be sure to see it in case it should light, for the instant the machine became grounded on either side, the current would flow through the lamp to ground and back to neutral.

One evening, while I was sitting at the desk the light suddenly flashed in my face. I grabbed the test lamp and tested from the positive booster-generator to the frame, but without results. When I applied the test lamp to the negative booster-generator and the frame the lamp lighted up brilliantly. I disconnected the machine from every possible source of potential, even from the operating busbar connections to the speed-limit device, but the lamp burned as brightly as ever. I finally gave up in disgust and sat down to think it over, when suddenly the light went out.

Nobody was near the machine at the time, but the assistant was just switching off the lights over the booster

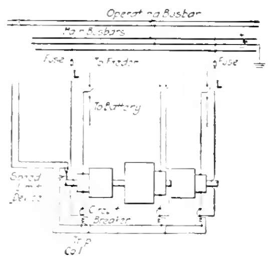


Fig. 1. Booster Connections

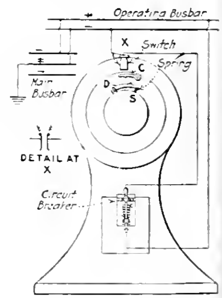


Fig. 2. Speed-Limit Device

set. There was a light over each of the four bearings. These were run in conduits up alongside of each bearing pedestal and clamped to it. I had the lights switched on and, sure enough, the lamp over the desk lighted up again.

One of the light sockets was broken, so this was replaced and the light over the desk stayed out with the machine lights on. I decided that the trouble had been located, concluding that, due to the broken socket, the lighting circuit had been grounded intermittently on the machine.

Two days later, while cleaning the commutator on the negative generator I received a jolt that made me jump. One hand was on the frame at the time, and the other happened to touch one of the brush-holders. The lamp was connected again and lighted up as before. The lights over the machine were out at the time, so it was concluded that they could not be the cause.

A few nights later the night operator again received a jolt from the machine, and at the same time the signal lamp indicated; but he was unable to find anything wrong.

One Sunday, shortly after this, I was sitting at the desk when the light suddenly flashed. The assistant was around the machine at the time and at that particular instant was wiping the end of the bearing and the inside of the hood over the speed-limit device. I had him go over it again and the signal lamp went out. Evidently the trouble was in the speed-limit device.

Fig. 2 illustrates the construction of this device, in which X represents the contact points or clips of the switch, C is the switch blade hinged on a pin screwed into the main bearing, and D is a weight hinged on a pin fastened to the shaft and revolving with it. Centrifugal force tends to throw this out when the shaft rotates, until at the predetermined speed it strikes the switch blade C, closing the circuit and tripping the circuit-breaker. The tripping speed is regulated by adjusting the tension of the small spring S. It was the switch C that caused all the trouble, for it was not insulated from the pin on which it was hinged; consequently, when the switch closed it grounded the machine.

To complicate matters the switch worked rather stiffly and made contact with one clip before touching the other. In wiping the machine the operator moved the blade C just enough to make it touch one clip without closing the switch, which would have tripped the circuit-breaker. This grounded the machine. Sometimes, due to the jarring of the machine, C would drop down again, or it would stay up until the next time the operator wiped it or sometimes for several days. With the signal lamp connected from the machine to ground, this also grounded the operating busbar.

What made the matter still more puzzling was the fact that the lighting circuit was grounded on the machine at the same time. To remedy the trouble we bored out the hole in C and put in a fiber bushing.

THOMAS G. THURSTON.

Chicago, Ill.

Fixing the Horsepower

A circular issued by the Bureau of Standards points out that at present there is no accepted authoritative definition of horsepower and, therefore, different equivalents of this unit in watts are given by various books. They state that inasmuch as the horsepower is a gravitational unit of power, it varies with latitude and altitude, being 552 ft.-lb. per sec. at the Equator and 549 ft.-lb. per sec. at the North Pole. They recommend the adoption of the horsepower as 550 ft.-lb. per sec. at 50 latitude (approximately that of London) and sea level and that the equivalent in watts be taken as 746.

There are too many engineering quantities for which there are no exact definitions, and it is to be hoped that the engineering societies will adopt standard values. The engineering congress to be held at San Francisco this fall would afford a fine opportunity to settle this and several other values, such as the British thermal unit.

While the writer believes in exact definitions for engineering quantities, he is of the opinion that the Bureau of Standards has over-estimated the commercial importance of the variation of the horsepower with latitude and altitude. It claims that this variation is enough to be of commercial importance and should be taken account of in engineering tests. The greatest error that could occur due to a variation in latitude and altitude is 1/3 of 1 per cent. Practically the only tests made at the present time are to determine the water rate either per indicated horsepower or per brake horsepower.

In the first case the error of the indicator is easily 1 per cent. and the personal error in working up the card can hardly be less than 1 per cent. Other variables, such as weighing the water, etc., will affect the result, so that any engine test can hardly be guaranteed to within 2 to 3 per cent. This would also be true when measuring brake horsepower. It would hardly seem worth while to take into account a variation of less than 1/3 of 1 per cent., when the known error is four to six times as much. This is on a par with boiler tests published from time to time, in which the results are carried out to the fourth and fifth places.

Another quantity which has even more effect on the water rate per horsepower with different altitudes than gravity is the pressure of the atmosphere. Yet the writer thinks that the decrease in back pressure with increase in altitude is not considered of sufficient commercial importance to be taken account of.

W. L. DURAND.

Brooklyn, N. Y.

[Of interest in connection with this letter is the editorial, "The Kilowatt and the Horsepower," on page 720 of the Nov. 17, 1914, issue.—EDITOR.]

Home-Made Feed-Water Heater

The criticism by E. H. Pearce in the issue of Dec. 8, 1914, on page 816, of the total result obtained from a feed-water heater which I described on page 502, Oct. 6, 1914, is entirely just. What I neglected to say was that the first heater gave such satisfactory results that five more were made, some of which were larger than the one described. I regret the blunder very much.

SAMUEL L. ROBINSON.

Providence, R. I.

Probable Cause of Boiler Explosions

Referring to the tabulated list in your issue of Jan. 26 of boiler explosions which occurred during the first half of 1914 and your editorial comment thereon that "these statements (of the probable cause) are not always as full and satisfactory as might be desired" is very true.

Tube failures and other conditions found after the explosions are not the true causes thereof, but are rather the results of conditions for which the tubes should not be held responsible, such as the nature of the feed water—too hard, containing mineral salts and other scale-forming constituents, suspended insoluble matter, or oil which was not filtered out. In the last case, boilers tubes of all kinds are apt to suffer, no matter how excellent they may have been when first put into the boiler.

It has been stated by Messrs. Stromeyer and Barron in a paper before the Society of Naval Engineers of Great Britain, that 1/8 in. of scale will raise the temperature of a boiler plate 300 deg. F., whereas less than 0.001 in. of oil will produce a far worse effect. They also state that the effect of oil is intensified where scale is present, therefore no effort should be spared to keep it out of boilers, not only when slight quantities are found floating on the surface of the feed water, but particularly when the oil is in the so called emulsified condition, as indicated by a cloudy appearance of the water.

There are many and adequate systems now in use to render hard and scale-forming water practically harmless, and also processes which remove every trace of oil from feed water, so that there is no good reason why boilers should be fed with poor water, which is the source of most boiler troubles and serious accidents.

It is to be hoped that state or Federal control will be made more strict in regard to the details gathered relating to boiler explosions, so that no particulars which might throw light upon the true causes of such disasters can be withheld from publicity.

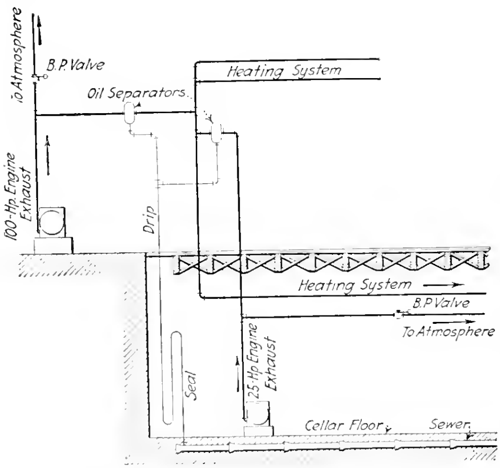
A. E. Krause.

New York City.

Trouble with Oil Separator

Referring to Mr. Goodwin's trouble with the oil separator described on page 207 of the Feb. 9 issue, as I have experienced similar trouble and overcame it successfully, I offer him a solution as per the following sketch.

He states that he carries eight inches of vacuum on his heating system. This will sustain a column of water about eight feet high in the pipes leading from his oil



Remedy Suggested for Trouble with Oil Separator

separators, and he should have at least that amount of fall from the bottom of his separator to the top of any seal that he uses. He does not state whether he ever has any pressure above atmosphere, and I take it for granted that he has, so he will need some seal to prevent steam blowing to the atmosphere when such is the case. His sketch shows only sixteen inches of head in one case and practically none in the other.

If he can get no more fall than he shows, it will be better to remove the seals entirely and run a line direct to the sewer with a swing check valve on as low down as possible, opening toward the atmosphere. This will give a head of water over the check to open it against atmospheric pressure, and the check will prevent entrance of air into the system. If he carries a pressure above atmosphere the addition of a steam trap of large capacity will prevent the loss of steam.

His basement separator cannot be given that much fall, but the one on the first floor can be arranged with the seal in the cellar instead of as located, and then it will work. Then he should take the exhaust from the engine in the basement and put it into the heating line at a point near where the other separator enters, moving the basement separator up there, so as to get enough fall to take care of it with a seal in the cellar. I have shown this in a sketch, using only one seal of larger capacity. Perhaps a separate seal for each would be more satisfactory, especially if the separators should be of different patterns or if the piping areas are restricted.

W. F. Meinzer.

Brooklyn, N. Y.

Referring to Mr. Goodwin's inquiry in the Feb. 9 issue regarding trouble with oil separators, the heating system is carrying eight inches of vacuum, which means that a head equivalent to eight inches of mercury, or about eight feet of water, must be carried on the separator side of the seal before the oily drips will overflow the seal.

From the sketch it is evident that the seals are set too close to the separators. My advice would be to run both drips together into a ½-in. lifting trap of the tilting type. When the trap dumps it will cut off the inlet and, consequently, the vacuum of the heating system, allowing the trap to discharge by gravity.

W. L. Durand.

Brooklyn, N. Y.

Referring to H. G. Goodwin's letter in the Feb. 9 issue concerning "Trouble with Oil Separators," it is suggested that the drip loop in connection with the larger separator should be dropped at least 4 ft. so as to give sufficient head in case of vacuum in the exhaust system, and a ½-in. vent inserted in the top of the last leg of this loop, and a check valve placed at the discharge end near the connection to the waste line. In reference to the smaller separator, it is suggested that the seal loop be replaced with some form of "grease trap" with a check on the discharge side.

Charles A. Nelson.

Chicago, Ill.

Chain Oiler Stopped

The oil chain in the outboard bearing on a new gas engine gave much trouble when the engine was first put in service, by stopping and allowing the bearing to get warm unless it was noticed in time and started again before the bearing was dry.

The cap was removed and the chain run around by hand. One joint between two links was rather stiff, but aside from this, there was apparently nothing wrong. The joint was limbered up, the cap replaced, and the engine started again, but before the week was out it was as bad as ever.

Upon a closer examination, the chain was found to be dragging on the bottom of the oil well. Three or four links were taken out, making the chain just long enough to clear the bottom nicely, which entirely eliminated the trouble.

Earl Pagett.

Coffeyville, Kan.

Safety Devices for Elevator Doors

Now that New York City has a law making it compulsory after a few months to have elevators provided with safety devices on gates or doors, discussion in POWER as to the working of these would be welcome. Several buildings in New York have such devices.

In the building where I am employed there is an electro-mechanical gate lock which has worked well for the last four years. The elevator cannot be started unless all gates in the shaft are closed tightly. When a gate is open a magnet placed over the operating valve (hydraulic car) is energized and, through an arm connected to the lever of the valve, prevents the latter from being moved by reason of the lever being held rigid. To bring out the relative merits of different devices for this service I hope discussion will be forthcoming.

W. T. OSBORN.

Newark, N. J.

[New York City has no such law. A proposed ordinance making the use of such devices compulsory and calling for the inspection of all elevators in the city was presented before the aldermen some time ago, but that body has not yet acted on it.—EDITOR.]

Starting Small Motors

W. S. Grimscom's diagnosis of the trouble experienced in starting a small shunt motor without a starting box when changed from driving a bottle-washing machine to driving a jig saw, referred to in his letter in the Jan. 12 issue, is quite correct, although he might have overcome the difficulty by shifting the brushes. The decrease in the starting torque was caused by the excessive current in the armature which set up a very strong magnetizing force from the neutral points of the armature across the polepieces.

The current in the armature of a direct-current machine produces magnetic poles at the neutral points which cross-magnetize the main poles, weakening the pole tip back of the neutral point and strengthening the one in front, the degree to which the polepieces are weakened and strengthened depending upon the position of the brushes. If the brushes are set slightly in front of the neutral point one is about equal to the other, but if set back of the neutral point the pole tip back of the neutral will be weakened faster than the one in front is strengthened, resulting in a decrease in the field strength. This accounts for the increase in speed of a motor by shifting the position of the brushes backward around the commutator against the direction of rotation. This shifting of the brushes, however, is limited by the sparking at the commutator.

The brushes may be set far enough back of the neutral point to cause no ill effects under normal working conditions, but when subject to an extreme overload current, as in Mr. Griscom's case, the distorting effect may be great enough to weaken the motor or even cause the armature to develop a backward torque.

Mr. Griscom could have remedied his trouble by giving the brushes a forward lead, thus causing the armature current to strengthen the polepieces instead of weakening them. He could also have improved his lamp starting device by short-circuiting it with a single-pole switch after the motor had been accelerated. Furthermore, a starting box could have been secured for this purpose for approximately the cost of the lamps and fittings, not to mention the more satisfactory operation of the driven machine when running under the proper conditions. For a temporary starting device a water rheostat could be used, and this could be made to give as satisfactory results, as far as starting is concerned, as a starting box.

The practice of starting shunt motors by connecting them directly across the line is not to be encouraged except in the case of small, slow-speed machines up to about ¼ hp. running at a speed not exceeding 750 r.p.m. and starting under very light load. If there is liability of the load stalling the motor while starting, a starting box should be used, even under these conditions. In a great many cases where trouble is experienced in the operation of small motors it is from no other cause than improper starting. In small series and compound motors the above rule need not be so rigidly followed, for the series field winding helps choke down the starting current, and as the current increases in the armature it also increases in the series field winding, causing a much greater increase in the starting torque than in the shunt machine, which will accelerate the load more rapidly than is possible with a shunt motor.

A. A. FREDERICKS.

New York City.

Selecting a Pump

In reading the article, "Selecting a Pump for General Service," by Charles L. Hubbard, in the Feb. 9 issue, I was disappointed at not finding more helpful information or suggestions, and more so in discovering a real lack of accurate knowledge and a tendency to erroneous statement.

It is stated that direct-acting steam pumps, engine- and turbine-driven plunger pumps and centrifugal pumps are adapted to conditions where the friction head in the suction pipe plus the elevation does not exceed fifteen to eighteen feet. Should it not be mentioned that a centrifugal pump is not as well adapted where there is a suction head, for it must be "primed" before it will pump water? Sometimes this is a comparatively easy operation, but often it is not. The various methods of "priming" a centrifugal pump might be stated, for certainly the availability of some method of priming might be a deciding factor in the selection of a centrifugal pump.

If the water supply of a power house must be pumped, the distance between the pump and the power house is hardly the only consideration when choosing the type of pump or determining whether to convey steam from the boiler house to the pump or "to drive the pump by an electric motor or gasoline engine" or "to install and care for a special boiler."

In pumping water from artesian wells the air lift is often desirable, but not "to increase the flow." The normal flow of a well cannot be materially increased by any method of pumping, and the air lift is not the type of pump which will always give a maximum delivery from a given-sized hole.

Mr. Hubbard says that "deep-well pumps have an efficiency of 40 to 50 per cent. and a slippage of 10 to 15 per cent." I have used several double-acting deep-well pumps which showed an efficiency of over 80 per cent. and had no slip whatever. Moreover, these pumps delivered much more water from the well than we could possibly obtain with an air-lift pump.

The statements regarding centrifugal pumps show a surprising lack of knowledge concerning this type, which is so widely used. Their efficiency is given as from 60 to 80 per cent. for the better types, working under the conditions for which they were designed. But, he says, "it is not possible to obtain as high an efficiency as with the best design of piston pumps when the latter are kept in first-class condition." The efficiency of direct-acting piston pumps is given as from 65 to 75 per cent. and of triplex pumps as from 60 to 80 per cent. According to the figures given, the efficiencies of all three types are remarkably similar.

The statement that "turbine pumps are designed for high lifts and are usually compounded in order to reduce the peripheral velocity and thus reduce the friction" is beyond my comprehension. Evidently, the design which characterizes volute and turbine pumps is not clear to Mr. Hubbard, nor is the reason for compounding, as he calls it. High heads require multi-stage pumps, and compounding does not necessarily decrease friction.

L. B. Lent.

Brewster, N. Y.

Vacuum Heating without Thermostats

In an article on "Vacuum Heating without Thermostats," by E. F. Henry, in Power of Oct. 20, 1914, the author states that "provision is always made for injecting water into the return pipe, so that the pump will not attempt to pump steam." This is a rather broad statement, and in this connection the writer wishes to say that if the traps on the radiators leak steam, then it is necessary to have jet water at the vacuum pump. However, if a properly constructed thermostatic trap is used—and there are such to be had—the necessity for jet water is obviated.

In the article referred to it appears as if the author has the idea that thermostatic traps are altogether impractical. The writer can cite a vacuum installation where the radiators are twenty-odd feet below the vacuum pump, yet the condensation from these radiators is lifted to the pump without the use of jet water. Attention is called to the fact that a twenty-foot lift, including friction in the piping, would correspond to a vacuum of approximately 18 in. At this pressure, water boils at 170 deg. F., approximately. This should reveal the fact that, in case any leakage occurred, the lifting of the condensation would be impossible, since the vacuum line would be quickly filled with steam. The writer can refer to many vacuum systems of heating where no jet water is being used, and where the vacuum pump is quite able to produce a vacuum of from 8 to 15 in.

Mr. Henry is quite right in saying that in some cases a thermostat has been removed without materially affecting the operation of the system. However, in such instances the radiator from whose trap the thermostat has been removed must be located at quite a distance from the vacuum pump, or at a point where the vacuum is low and the discharge from the radiator has ample opportunity to cool before coming to a portion of the return line where a higher vacuum is carried, and even then, trouble is likely to occur.

Theoretically speaking, the substitution of globe valves for the thermostatic trap at the return end of the radiator might work very well, but from a practical standpoint it will be almost impossible to throttle the return from each radiator so that it will allow only the condensation to pass, especially since there is no means of telling just the amount of openings that would be obtained by turning valve handles each a certain distance, because different valves would give different openings. Besides the uncertainty of valve opening it must be remembered that condensation in a radiator may be increased at times as much as 100 per cent. or on the other hand may be so much reduced as to allow steam to blow through. The use of jet water at the pump may prevent the pump from pumping steam, but in such a case the steam is in the return line, up to the point where the jet water enters. In such cases one of the main advantages of a vacuum system is curtailed, to say nothing of the complications usually brought about by the use of jet water, which destroys steam, and it is generally also the case that surplus water has to be discharged from the system.

D. N. Crosthwait, Jr.

Marshalltown, Iowa.

We are given to understand by E. F. Henry's statements under "Vacuum Heating Without Thermostats" that he refers to all types of vacuum return valves, although it should be borne in mind that the term "thermostatic" would be more proper, and then strictly correct only when applied to those valves which operate by the expansion of a volatile liquid inside a disk, as distinguished from the float type of valves. His reference to the virtue of the vacuum system as means of abstracting more heat from the steam "before it is thrown away" must be intended to apply only to the use of exhaust steam.

The scheme Mr. Henry proposes has been employed satisfactorily on gravity systems with the return open to the atmosphere and no pump. This is similar to the so called vapor system. With this system, however, a special valve is used that can be shut off and so set, that when it is wide open only the right quantity of steam is admitted to the radiator. This scheme could also be used with a vacuum pump on the return line, provided the difference between the supply and return were always the same—a condition that would be impossible to maintain in practice and would immediately be upset by the least change in either the steam pressure or the vacuum in the return.

With hot-blast heaters, where the rate of condensation changes with every variation of the outside temperature, the scheme would be impractical.

If globe valves are used on the radiators, as suggested, another disadvantage would be that the heating units could never be shut off unless two valves were used.

Taking all points into consideration, I would not advise any engineer to install a heating system and put a vacuum pump on the return line and use no vacuum valves; neither would I advise changing over an existing system with the sole idea of a large saving in operating cost, for there will be none.

W. L. Durand.

Brooklyn, N. Y.

Electric-Light Rates

When electric plants first came into use they furnished current for lighting purposes only, and their total cost of doing business was, therefore, charged up to the current sold for this purpose. It did not take long to learn that if the same equipment which was installed to provide for light customers could be operating in the daytime, they could afford to sell current cheaper during the day than at night, provided they could continue to charge the cost of doing business up to the light customers. This led to the conception and final birth of the present rate-making "theories."

What citizen or court would permit a street railway to charge a passenger riding on a car during rush hours a fare several times larger than that charged at other times of the day? Can you justly ask a street-car company to charge less for a ride in an owl car just because the load in the power plant at that time is in the valley of the load curve, and because they ought to be glad to have "even a little revenue during that time"?

The electric-light companies seek to show that they are the one exception and that they should be allowed to charge up a greater proportion of their cost of doing business to the small consumer who cannot "kick back," and a lesser proportion to the larger customer who can.

F. F. CHANDLER.

Indianapolis, Ind.

Vibration Due to Missing Blades

We have in our plant a 100-hp. impulse single-stage turbine running 12,000 r.p.m. The wheel is 24 in. diameter and mounted on a shaft whose diameter is 7/8 in. There are 196 blades on the wheel and the peripheral velocity is, as usual, quite high, being 1256 ft. per second.

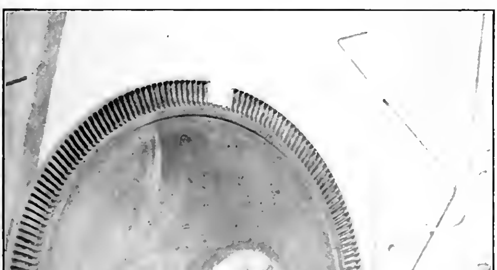


FIG. 1. TURBINE WHEEL, SINGLE-STAGE, UNBALANCED BY LOSS OF FOUR BLADES

An examination of the turbine to discover the cause of excessive vibrations of the shaft showed a gap in the rim where four blades had broken off (Fig. 1). Wheels running at this high speed must be perfectly balanced. The loss of a single blade will cause noticeable shaft vibrations.

The blades of these single-stage turbines are made with bulb-shaped shanks which fit into slots in the rim of the disk. The outer ends of the blades are flanged to

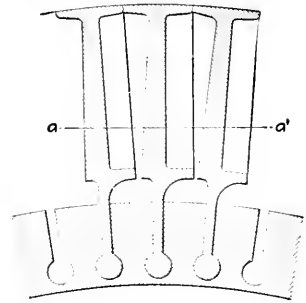


FIG. 2. SECTION OF BLADING

form a continuous rim of metal (Fig. 2). No special apparatus is needed in replacing the blades. In this case the wheel and shaft were removed from their bearings, the shanks of the broken blades punched out and new blades inserted by driving in from the side. The flanges were then filed true.

Moisture in the steam, small particles of scale, etc., are probably responsible for the breakage. There is no separator in the steam line, though one should be put there.

R. S. HAWLEY.

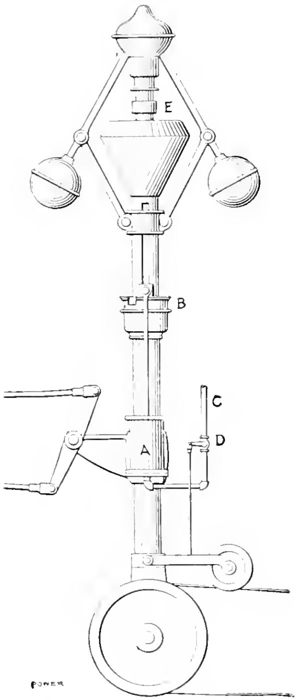
Golden, Colo.

Blocking up the Governor

The direful consequences of blocking up a Corliss engine governor have been so often impressed upon our minds that, with many of us, the faculty of reasoning whether the practice is always hazardous has either never been allowed to awaken or has been quickly inhibited at its inception. The opinion is prevalent that no argument, however reasonable, can justify this practice, and that even to discuss it on the negative side is in itself criminal. Yet there is scarcely any danger—I do not say peril—that cannot be risked with impunity at some opportune time, and certainly there exist conditions under which the governors may be blocked up with comparative if not complete safety. In case of large engines operating under fluctuating loads it is a decided advantage in economy.

Engineers employed in street-railway plants know that, during certain periods of the day, when the peak loads are reached, it is sometimes necessary to prevent the governor weights from dropping below the point of maximum cutoff by fastening up the starting pin. Judging from many an attendant's apprehension at that particular time, however, few seemingly understand that the breaking of a governor belt on one out of two or more engines driving generators connected to the same set of busbars will be attended with little if any evil consequences. Even in industrial plants, in which two or more engines are connected mechanically by means of the factory shafting, the danger is slight provided (and here is where reason and common sense enter) the load is, while the pin is up, at all times equal to, or greater than, the full-load capacity of the largest engine then in operation.

The case is similar to two horses drawing a loaded wagon. One of them may be fresh and impatient, smarting under the restraint of its harness. It prances, jerks and endeavors to run away with the load, but finds it beyond its strength to do so and therefore it is forced to follow the gait of its more conservative brother. Suppose



Common Flyball Governor

two engines operating under similar conditions of heavy load, and suppose that the governor belt on one breaks when the starting pin is up. What will happen? Simply this, the other engine will obligingly give the unrestrained one all the load it can take and the latter is immediately forced to adopt the speed of the other engine. It really does not matter whether the governor revolves when the load is so heavy as to bring the weights down on the starting pin.

To sum up, my point is that under conditions as stated an engineer may attend to his ordinary duties with as little concern about his engines as at any other period of the day, and my only justification for so elaborately enunciating it is that we all have enough trouble without borrowing more.

The great danger lies in the neglect to release the starting pin when the load becomes light, and—but this introduces another matter—carelessness, which is not the subject of this writing.

Regarding the one-engine plant, I can only repeat the frequently iterated admonition never to block up the governor unless an independent speed-limiting device is part of the engine's equipment or the ingenuity of the chief engineer has removed, or at least diminished, the certain risk attendant upon the practice. Where necessity spurs, it really is not a difficult matter to devise some scheme to lessen the danger, as the many creditable efforts that have been described and illustrated in power-plant papers prove.

In one plant I was shown an ingenious device which I mention because of its surprising simplicity. The type of governor and the essential details are shown in the illustration. *A* is the oil dashpot, in the bottom of which is inserted a loose piston of a thickness equal to the depth of the step in the movable rest-collar *B*. Leading from below the throttle is the ⅜-in. pipe *C*, which communicates with the bottom of the dashpot and has the cock *D*, whose handle connects with the arm of the idler, as a shutoff.

It is apparent that the arrangement is such that when the governor belt breaks, the idler will fall and open the cock, which, by supplying steam below the loose piston, should force the governor weights to their highest position against the collar *E*. If one will remember that the piston is always lubricated by the oil contained in the dashpot, and that the steam-cock *D* is also prevented from sticking by the same oil seeping past the loose piston into the pipe, I think it will be agreed that its success is probable if the diameter of the dashpot allows of sufficient area. In no way does it lessen the utility of the dashpot.

R. O. Richards.

Framingham, Mass.

Meter and Pump Trouble

In a steam plant using water from the city main the water meter got out of order, the readings being less than they ought to be. The cause was located in the layout of the triplex power boiler-feed pump, which had a bypass from the discharge pipe to the suction.

There had been a light load for a couple of months and the temperature of the feed water entering the boilers was higher than at normal load. The bypass was slightly open most of the time, as that was the only way to reduce the water-supply and to get a steady feed. This constant circulation of hot water back to the suction pipe caused considerable heat to get to the meter, which was located near the pump, and put it out of order.

When a new meter was installed two horizontal check valves were placed between the meter and the heater. Later, there was a complaint of a pulsation in the mains of about 12 lb. I connected in the suction line an air chamber made of 4-in. pipe capped on both ends. The lower cap was tapped and made up with a 1½-in. nipple a valve and another nipple screwed into a tee on the suction line. The body of this air chamber was drilled and tapped at the top and bottom for ⅛-in. pet-cocks, and these with the valve kept the chamber clear of water and recharged with air. Since then there has been no pulsation or water-hammer.

John Powers.

New Bedford, Mass.

Inquiries of General Interest

Calking of Butt and Double-Strap Joint—Where is the calking done on a butt and double-strap boiler joint?

R. G. M.

On the outside along the edge of the narrower strap, where the rivets are close enough together to obtain a good calking pitch.

Steam Lap of Slide Valve—What determines the amount of lap that should be given to the steam side of a D-slide valve?

J. D. P.

The travel of the valve and the angular position of the crank at the time of cutoff.

Delivery in Duty Trials of Pumping Engines—In making duty trials of pumping engines what is the usual method of determining the quantity of water delivered?

A. E. W.

The delivery is usually determined from plunger displacement, after making due allowance for slippage and leakage, which should be ascertained by actual test.

Units of Compression—What is meant by the term "units of compression" as applied to the operation of a reciprocating engine?

S. C. N.

The expression has been used in designating the number of clearance volumes displaced by the piston during its compression of the exhaust. If, for instance, compression of the exhaust begins at the completion of 75 per cent. of the return stroke, then if the clearance is 5 per cent. there will be $(100 - 75) \div 5 = 5$ units of compression.

Cleaning Heating Coils of Grease Deposits—How can steam-heating coils be cleaned of grease that has been deposited by the use of exhaust steam?

W. C. C.

The grease can be removed by filling the coils with a solution of caustic soda made in proportions of about 20 lb. of soda to a barrel of water. The coils should be filled with a warm solution, and after having them filled for about 24 hr. the solution should be drained off and replaced with clean warm water, which should be blown out of one coil at a time with high-pressure steam.

Setting Boilers with Same Height of Tubes—When two horizontal return-tubular boilers, respectively 72 in. and 60 in. in diameter, are set together, should the upper rows of tubes of the boilers be at the same level, so that there will be the same height of safe water level in each boiler?

S. L. G.

There will be no advantage setting the boilers with their upper rows of tubes at the same level, for dependence cannot be placed on maintaining the same water level by connecting the boilers together below water line, as the proper water level must be maintained by regulation of the feed through a feed stop valve for each boiler.

Relative Economy of Engine with Increase of Speed—If the main receiving pulley on a jack shaft is increased in diameter from 72 in. to 84 in., requiring the engine to make nine more revolutions per minute to drive the shaft at the same speed, will not more steam be required by the engine for driving the same power?

E. H.

There will be $^{72}/_{84}$, or $^{6}/_{7}$, as much work required of the engine per stroke and less steam will be required per stroke, and for the same economy the consumption of steam would need to be only $^{6}/_{7}$ as much per stroke, but whether more or less steam would be required per hour for developing the same power would depend upon relative points of cutting off and other conditions affecting economy.

Connecting Two Engines to the Same Receiving Shaft—For obtaining the power of both engines would it be practical to connect a Corliss and an automatic engine to the same receiving shaft?

J. W. D.

For good regulation it would not be practical, as the governors would not synchronize. An approach to ordinary regulation, though only for gradual loading and unloading, could be obtained by adjusting the governor of the automatic engine for carrying the load up to a point where its speed would become reduced to the working speed of the Corliss governor. Then, with the automatic governor blocked against admission of a greater amount of steam, the Corliss engine could pick up any additional load with a reduced speed. But any sudden change of load would give rise to spasmodic variations of speed of unusual extent and duration. Besides the uncertainties of speed regulation there is an additional objection to connecting the engines as proposed, especially when they are widely separated, arising out of the danger of starting up one engine and sustaining a water smash in the cylinder of the other.

Running Shunt Motor as a Dynamo—At what speed will a 30-hp., 115-volt, 120-r.p.m. shunt motor have to be run when used as a dynamo?

H. G. C.

It will have to be run faster as a dynamo than as a motor to deliver the same voltage to the line, because of the drop in the armature circuit. In the motor the speed will be great enough to produce a counter-electromotive force equal to the difference between the impressed voltage and the armature (IR) drop. In the dynamo the speed must be such as to generate an electromotive force which, minus the IR drop, will equal the line voltage.

To solve the problem accurately it will be necessary to know the armature resistance. Assuming this to be 0.08 ohm, then as a motor rated at 30 hp. and 115 volts will have a full-load current of about 165 amp., the armature drop would be approximately

$$165 \times 0.08 = 13 \text{ volts.}$$

The counter-electromotive force would be

$$115 - 13 = 102 \text{ volts}$$

generated at 120 r.p.m. Run as a dynamo, the armature would have to generate

$$115 + 13 = 128 \text{ volts.}$$

Therefore, as a dynamo, the speed would be

$$120 \times 128 \div 102 = 150 \text{ r.p.m.}$$

Changing Speed of Induction Motor—How can the speed of an induction motor be changed?

F. H.

There are five ways in which this may be accomplished, namely: (1) Changing the applied voltage, (2) changing the rotor resistance, (3) varying the number of poles, (4) operating in cascade, and (5) varying the frequency.

The usual means under the first method is the use of a compensator, or autotransformer. This method does not give very satisfactory speed regulation; the efficiency and power factor decrease with the speed.

In varying the resistance of the rotor winding a constant speed is not obtained over the torque range of the machine, but changes with the torque. As in the first case, the efficiency decreases with the speed.

The third method is applicable when only two speeds are desired; as the number of speeds increases, the necessary wiring becomes cumbersome and complicated. The power factor is not appreciably affected in this case, but as it is necessary to open and close the supply circuit in making the change, variation in primary current and fluctuations in voltage are apt to result.

In cascade operation two motors are necessary, the rotors being connected together mechanically. The stator of the first is connected to the supply and its rotor (which is of the slip-ring type) feeds the stator of the second motor; the rotor of the latter is usually connected to an adjustable resistance. This method is frequently used where the speed changes are frequently made, and the horsepower relatively high, such as in electric locomotives. The power factor and efficiency of two motors in cascade are less than a single machine of the same capacity.

The fifth method mentioned, namely, varying the frequency, is usually impracticable. ?

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Just for Fun

[More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.]

While I was employed in a large plant, it became necessary to remove the bonnet of a 36-in. valve. The assistant engineer, the happy owner of License No. 1, was put on the job. The valve bonnet had been unmolested for many years. After he had worked for about one hour, I discovered that he had twisted off 31 of the stud bolts. Two men had to work twelve hours drilling out the studs with a ratchet and "old man" to repair the damage. *Answer*—Always cut the nuts with a chisel. Nuts are plentiful and split easily with the grain of the metal.—*James Browning, Joliet, Ill.*

A few years ago, while I was running a lighting plant in a small country town, a high-school professor visited the plant one night with his class in physics, and asked my permission to explain the electrical apparatus to the boys and girls. I gave my consent after cautioning him to be careful not to let anyone get hurt. Then I prepared to listen to the discourse myself, thinking this would be a good chance to add to my small store of electrical knowledge.

After lining his class up in front of the switchboard, he said, "Now, first we will have a little demonstration in magnetism," and taking a large jackknife from his pocket, before I realized what he was doing he placed it squarely across the main switch. The report and flash that instantly followed were appalling. The professor's hand was badly burned, and the switch had two large scallops melted out where the knife had touched it, and the back springs, handle, and blades of the knife were fused together. The professor explained that he thought the switch would attract the knife.—*C. M. Knowland, Louisville, Ky.*

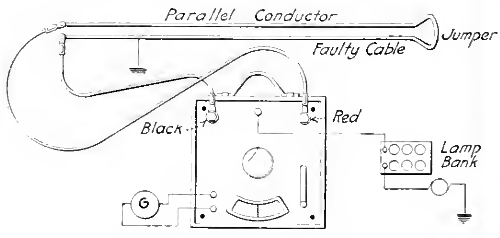
In an artillery electrical plant an officious artillery engineer annoyed the electrician sergeant very much by aimlessly playing with the apparatus. The sergeant, therefore, got some electric primers and concealed them in a cable conduit and connected them to the dead side of several switches, and then found important business elsewhere when the officer appeared again. Of course, the officious one started his usual performance, but very soon heard an explosion, and continuing his monkey business, the noise was soon repeated. He couldn't seem to locate any trouble, and it "got his goat." He hunted up the sergeant and breathlessly said: "I say, sergeant, you'd better go down there and see what the trouble is, for every time I close a switch there is an explosion." And, of course, the sergeant hurried away to make an investigation.

Some years ago a central station in this vicinity was operating several old Thomson-Houston arc machines. A policeman on that beat frequently stepped in for a few minutes. One night he came in looking kind of glum and remarked that he wasn't feeling very chipper—kind of stiff and rheumatic. When no one was looking he took hold of both brushes of one of the arc machines. He said afterward it was pretty harsh treatment, and one dose was enough, but maintained it knocked the rheumatism out of him.—*H. L. Strong, Yarmouthville, Maine.*

Portable Fault Localizer

A portable fault localizer, for quickly locating a ground on an electric cable has been developed by the Westinghouse Electric & Manufacturing Co. The position of a ground is read directly from the dial in per cent. of length of the defective cable. It is an application of the wheatstone bridge, with all the necessary apparatus contained in one portable case wired for connection to the circuit to be tested. Its use assumes that the cable is grounded at only one point and that a parallel conductor of the same length and resistance is available.

After proper connections are made, a dial on the instrument is revolved by means of a knob in the middle of the localizer until the galvanometer shows no deflection when the key is closed. The reading of the meter then gives the percentage of length of the feeder from the point where the test is being made to the location of the ground, assuming the total length of the feeder to be 100



OUTFIT FOR LOCATING FAULTS

per cent.; the red scale indicating that the ground is on the conductor connected to the binding post marked red, and the black scale indicating to the binding post marked black. Direct current only is used in these tests.

The variable-resistance arms consist of two loops of low-resistance wire attached to the side of a revolving disk, upon which the dial is attached, so that contact is easily made from two brushes attached to the case and connected to the galvanometer terminals. As the disk is revolved the point of contact between the brushes and the resistance loops is thus varied, as in the slide-wire bridge. The dial is calibrated in percentage of the length of the conductor tested, so that the reading is direct.

Rules for Thickness and Weight of Lead Pipes

The thickness of lead pipe required to withstand a given pressure may be calculated by the following formula:

$$T = \frac{0.433 \times H \times R}{2745}$$

in which

T = Thickness of pipe in fractions of an inch;
H = Head of pressure in feet;
R = Radius of pipe in inches;

from which we get

$$T = 0.0001578 \times H \times R$$

For lead a factor of safety of 10 is required, hence the last rule becomes $T = 0.001578 \times H \times R$

or, if we take D = the diameter of pipe in inches, instead of radius R, we get

$$T = 0.000789 \times H + R$$

The formula for the weight of lead pipes is

$$W = 3.86 \ (D^2 - d^2); \text{ or } 3.86 \ (D + d) \times (D - d)$$

in which

W = Weight of pipe per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
3.86 = A constant.

Oil Engine for Off-Peak Load

By L. H. Morris

SYNOPSIS—Saving effected in a small municipal plant where an oil engine was installed to handle the load between midnight and 7 p.m., the steam plant handling the evening load.

At present much attention is being given to the oil engine in the West and Southwest, where plants of small and medium size are to be installed. However, it is not alone in new plants that the oil engine finds application, but also in existing steam plants where additional power is necessary, or where a more economical engine is found desirable to handle the off-peak load. This is especially true as regards the small electric-light plants of capacities up to three or four hundred kilowatts, where the load from midnight until morning consists of the street lights and a few residence lights, and where the day load consists of a few motors of small power. In such cases a steam plant of a size to carry the maximum evening load must operate at a low load factor during fifteen to eighteen hours a day, and the resulting cost per kilowatt-hour is often too high to show a fair profit on the investment.

A situation along these lines arose in a municipal light plant with which the writer is connected. This plant, including the pole lines, etc., was purchased from a private company some years ago at a total cost of $35,000. The power house contained a 125-hp. noncondensing Corliss engine belted to a 75-kv.-a. alternator, a 75-hp., high-speed engine belted to a 40-kv.-a. alternator, two 72-in. by 18-ft. and one 54-in. by 16-ft. tubular boilers, together with the usual switchboard, piping, pumps and heaters. A fair estimate of the replacement cost of the plant, including the building, would not exceed $12,000, leaving the outside system to carry the remaining $23,000, less the franchise value; although the entire plant and system could be replaced for less than $20,000.

The load consisted of the lights for the entire town, a few small motors, and a 15-hp. motor driving the city water-works pump. The amount of water pumped was approximately 72,000 gal. per day, the bulk of this being used by the railroads and mill. This pump was thrown onto the line whenever the engineer found the water in the standpipe getting low.

The plant has been under municipal control for about four years, and at no time have the earnings been as large as was expected. This, of course, led to much dissatisfaction and caused the resignation of several plant operators. Finally, there came into office a new set of city officials who were committed to a policy of running the plant on a profitable basis, or of turning it over to a private company.

This ultimately led to an investigation of the oil engine, especially the high-compression type. It was generally understood that the plant required a 150- and a 75-hp. engine. The investigation readily proved that this type of engine would have a high maintenance charge and would require higher-grade engineers than the town could afford to employ, even though the fuel cost be exceedingly low. The medium-compression or semi-Diesel was finally decided upon, but the entire scheme was abandoned upon learning the cost of the two units.

Finally, a new superintendent was employed, who decided to approach the matter in a more systematic way and, therefore, ran a test on the plant with the idea of learning the exact load and the total amount of fuel used per hour.

Curve No. 1, Fig. 1, shows the hourly load for the twenty-four hours. It will be noted that the output is below 40 kw. from midnight until 6 p.m., while from 6 p.m. until 11 p.m. the load is considerable. Furthermore, the crosses marked 1, 2, 3, etc., indicate the hours during which the pump motor was in operation, from which may be judged the load at these hours with the pump motor eliminated (this motor required 13 kw.). Curve No. 2 shows the fuel cost per hour, while curve No. 3 covers the total fuel and labor cost per hour.

An examination of these curves shows that the coal used per hour was out of all proportion to the kilowatt output. It is readily admitted that the excessive fuel charge is open to criticism, and it is self-evident that

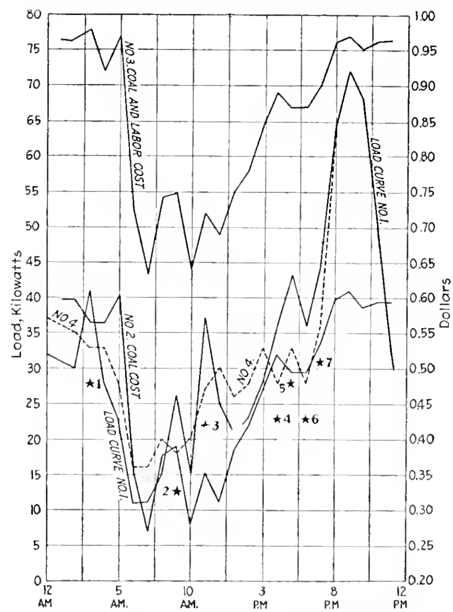


Fig. 1. Hourly Load of Steam Plant

either the engines were in bad condition or the firing was bad. A test on the high-speed engine showed that it used 59 lb. of steam per kilowatt-hour at full load, which, while high, is not excessively so, in view of the belt loss. Furthermore, a casual investigation of the firing method in vogue during the hours of light load indicated that the greater part of the loss was in the boiler room. However, even if the firing conditions had been improved, the fuel cost would still have been high, because of the varying load.

As already mentioned, the original idea of purchasing two oil engines had been abandoned on account of the cost; therefore, a plan was adopted whereby the plant could use both a small oil engine and one of the steam engines.

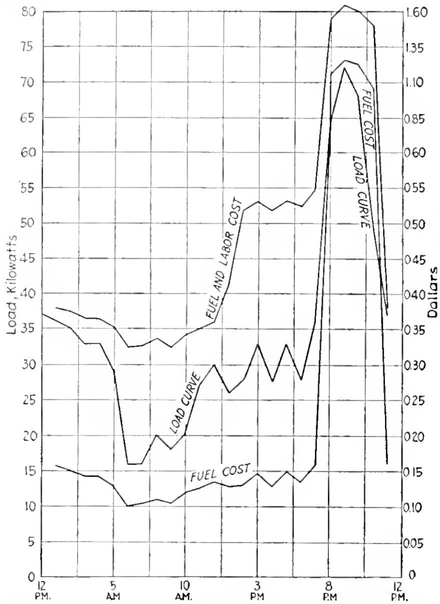


Fig. 2. Hourly Load of Steam- and Oil-Engine Plant

As a means of evening up the load a 4x6-in. duplex power pump was installed to handle the city water, this being driven by a 5-hp. motor operating twenty hours a day, while retaining the centrifugal pump and motor for additional fire protection. This would cause the load to take the form of curve No. 4, Fig. 1. In this way the load would not exceed 40 kw. during nineteen hours of the day; and as the load each day was almost uniform, it could be assumed with safety that this value would not be exceeded for some time to come.

A 60-hp. medium-compression oil engine was purchased at a total installed price of $3800. This engine was of the single-cylinder horizontal type with a guaranteed fuel consumption of 0.067 gal. of desulphurized fuel or crude oil per horsepower-hour, and furthermore was to have a 25 per cent. overload capacity. This was belted to the 40-kv.-a. alternator already installed.

The setting of one of the 72-in. by 18-ft. boilers was altered so that oil could be used as fuel. This involved but slight expense, as the alterations consisted of building a checkerwork of firebrick on the bridge-wall and of covering the grates with a layer of cinders and firebrick. This type of furnace is not ideal for the use of oil, but is one quite generally used where there is a possibility of changing back to coal. Some time in the past the plant had used oil as fuel when it could be obtained at 70 to 80c. per barrel, and consequently it was not necessary to purchase a burner, pumping outfit or storage tank.

The plan of operation was to run the oil engine from midnight until 7 p.m. and then cut in with the steam engine, it being easy to raise steam in about thirty minutes. The oil cost 3c. per gallon delivered. Very little oil was actually used under the boiler from 11 p.m. to 12 p.m., as the steam was allowed to go as low as 50 lb. during this hour, so that the oil saved here made up for the oil used in steaming up between 6 p.m. and 7 p.m. This saved about 1000 lb. of coal that would have been used in banking fires and steaming up.

With this method of operation it was possible to dispense with one man and to raise the salaries of the two engineers. The night engineer worked from 7 p.m. to 7 a.m., the day engineer from 7 a.m. to 7 p.m., while the fireman's hours were from 12 noon to 12 midnight. This allowed two men to be on duty during the heavy load when the steam plant was in operation, and also gave the day engineer time to do repair work each afternoon.

As regards the total saving; it was impossible, of course, in ordinary operation to find any one day's load which corresponded exactly with the day's run plotted in Fig. 1. Consequently, arrangements were made to run a twenty-four-hour test on a Sunday, wherein each hour's load was made the same as on the first test with the exception of the waterworks load, which was distributed over twenty hours instead of seven.

Accordingly, on Saturday night the standpipe was filled, a water rheostat was arranged for manipulating the load and at midnight and each hour thereafter the load was kept to the proper value. It was thought best not to run the pump motor, as it was necessary to take care of the commercial load, which might be slightly larger than during the former test.

Fig. 2 shows the results of the test plotted as to load, fuel cost and total cost. The oil engine, while handled by the city employees, did not come up to the guarantee, but the ease of operation and apparent reliability more than offset the increased fuel consumption. The steam plant used a large amount of oil per kilowatt-hour, causing the fuel cost to be much higher during the peak hours than it was during the corresponding hours of the first test. However, all banking of fires was avoided, with a resultant saving of fuel, and all things considered, the oil proved more satisfactory.

For comparison, the costs per day under both conditions are given below, showing a net saving of $2209.70 per year, which represents a return of 57½ per cent. on the cost of the oil engine and the alterations to the boiler. As soon as the city can raise more funds, a larger oil engine will undoubtedly be installed.

	Steam Plant	Steam and Oil
Fuel: coal at $1.80 per ton, oil at $0.03 per gal.	$11.60	$7.29
Labor: 2 engineers at $72 per month, 2 firemen at $60	8.80	
2 engineers at $80, 1 fireman at $60		7.33
Total cost per day	$20.40	$14.62
Net saving per day		$5.78
Net saving per year		2209.70
Cost of engine and alterations		4200.00
Cost less value of old steam engine		3850.00
Saving on investment		57½ per cent.

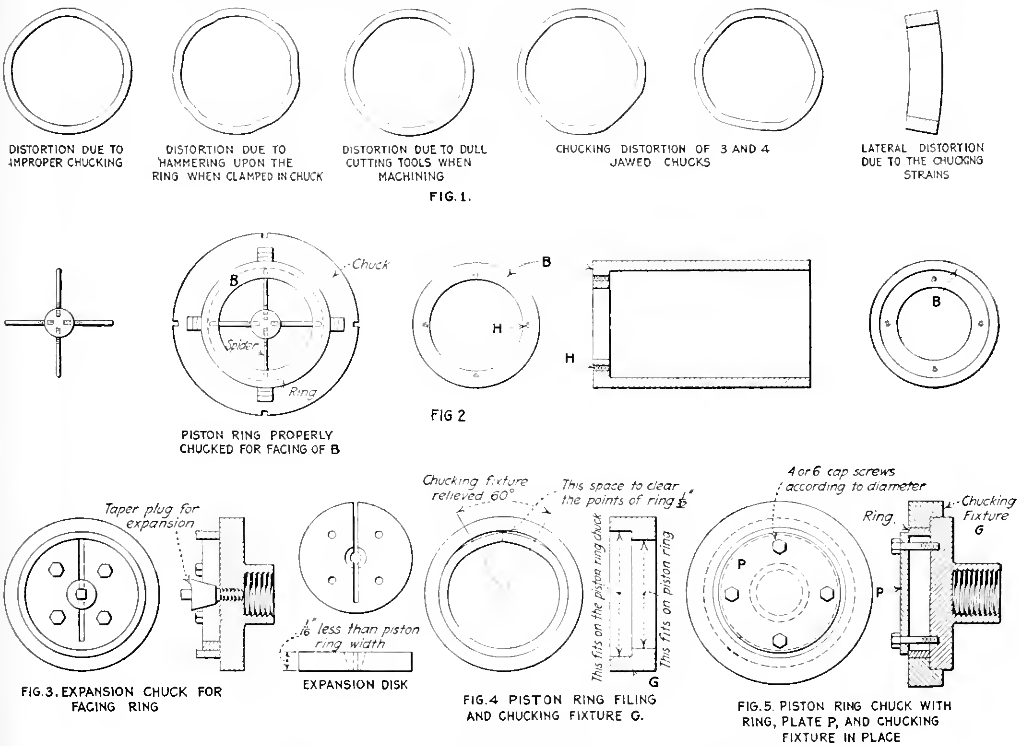
The amount of lubricating oil was practically the same on each test owing to the bad condition of the high-speed engine.

Machining a Piston Ring

By G. Strom

A piston ring with a plain surface will wear to its bearing in four or five hours if properly made and fitted. The real cause of leakage is distortion of the ring in manufacture. Fig. 1 shows some of the effects of such distortion.

To produce a properly fitting piston ring, a casting of the required dimension is secured. A spider with the same number of screws as there are jaws in the chuck is then inserted and the screws tightened slightly, Fig. 2; this is to prevent springing the casting when chucking.



Process of Machining Piston Rings and Some Distortions

The casting is then placed in a lathe, chucked upon the spider screws and end *B* faced true. Holes *H* are drilled for bolts or tapped for capscrews for bolting to the faceplate. This must be faced true. The casting is machined to the required dimensions, allowing $\frac{1}{32}$-in. thickness and width for re-turning. In both machining and cutting-off operations the tools must be kept sharp, otherwise the ring will have a wind impossible to remove.

The ring is then placed on an expansion chuck, Fig. 3, to have its sides faced as follows: Place the ring, which should be a sliding fit, on the expansion disk, loosen the four capscrews slightly, press the ring against the chuck plate with a board, tighten the taper plug and the capscrews and then all is ready for facing. Three light cuts are required on each face, using $^1/_{100}$-in. feed.

After both sides of the ring are finished it is split diagonally, using a hacksaw or milling cutter, and fitted into a chucking fixture *G*, Fig. 4, which is $\frac{1}{16}$ in. larger in diameter than the finished ring and is relieved $\frac{1}{8}$ in. for one-sixth of the circumference opposite which the cut in the ring is placed. This is to allow the points to spring slightly outward and when turned off will prevent the points from "digging" into the cylinder.

The fixture with the ring inside is put on the special faceplate *P* and tightened. The chucking fixture is then removed and the face of the ring turned. Only one ring at a time should be chucked; if several are placed together they will buckle and be spoiled. A diamond-pointed tool should be used with a $^1/_{100}$-in. feed per revolution. Three cuts should be taken across the ring with a sharp tool, allowing $^6/_{1000}$ for the finishing cut. The finished ring should be the diameter of the cylinder plus $^1/_{1000}$ for wearing in, and no filing is necessary. The piston should have dowel pins to keep the ring from rotating. In slipping the ring on the piston and into the groove a tin shield should be used instead of wire nails, and the like, as is sometimes done.

In fitting new rings no allowance need be made for circular expansion. This will leave the joints tight when the ring has worn to a bearing and there will be no blowing or leakage.

It might be argued that so tight a ring would score and cut itself and the cylinder. This is not true. A tight piston will quickly score its cylinder, but a tight ring will not. The foregoing is for rings ranging from 3-in. to 18-

in. diameter and $\frac{1}{8}$ to $\frac{7}{16}$ in. thick and from $\frac{3}{16}$ to 1 in. wide. The following table gives the dimensions of several sizes of rings and the allowance for tension.

PISTON RING DIMENSIONS

Diam. of Finished Ring, In.	Width of Finished Ring, In.	Thickness of Finished Ring, In.	Diam. of Ring before Splitting, In.	Allowance for Tension on Ring, In.
18	1	$\frac{7}{16}$	$18\frac{5}{16}$	$\frac{5}{16}$
17	1	$\frac{7}{16}$	$17\frac{5}{16}$	$\frac{5}{16}$
16	1	$\frac{7}{16}$	$16\frac{5}{16}$	$\frac{5}{16}$
15	$\frac{7}{8}$	$\frac{13}{32}$	$15\frac{5}{16}$	$\frac{5}{16}$
14	$\frac{7}{8}$	$\frac{13}{32}$	$14\frac{5}{16}$	$\frac{5}{16}$
13	$\frac{7}{8}$	$\frac{13}{32}$	$13\frac{1}{4}$	$\frac{1}{4}$
12	$\frac{3}{4}$	$\frac{3}{8}$	$12\frac{1}{4}$	$\frac{1}{4}$
11	$\frac{3}{4}$	$\frac{3}{8}$	$11\frac{1}{4}$	$\frac{1}{4}$
10	$\frac{5}{8}$	$\frac{11}{32}$	$10\frac{3}{16}$	$\frac{3}{16}$
9	$\frac{5}{8}$	$\frac{11}{32}$	$9\frac{3}{16}$	$\frac{3}{16}$
8	$\frac{9}{16}$	$\frac{5}{16}$	$8\frac{3}{16}$	$\frac{3}{16}$
7	$\frac{9}{16}$	$\frac{5}{16}$	$7\frac{5}{32}$	$\frac{5}{32}$
6	$\frac{3}{8}$	$\frac{9}{32}$	$6\frac{5}{32}$	$\frac{5}{32}$
$5\frac{3}{4}$	$\frac{5}{16}$	$\frac{3}{16}$	$5\frac{29}{32}$	$\frac{5}{32}$
$5\frac{1}{2}$	$\frac{1}{4}$	$\frac{5}{32}$	$5\frac{21}{32}$	$\frac{5}{32}$
$4\frac{3}{4}$	$\frac{1}{4}$	$\frac{5}{32}$	$4\frac{29}{32}$	$\frac{5}{32}$
4	$\frac{1}{4}$	$\frac{5}{32}$	$4\frac{1}{8}$	$\frac{1}{8}$
3	$\frac{3}{16}$	$\frac{1}{8}$	$3\frac{1}{8}$	$\frac{1}{8}$

Extension of the Dunston Station

The much discussed Dunston Station at Newcastle-upon-Tyne has been undergoing extensions, although completed only four years ago. An agreement was entered into with the Teams Byproducts Co., Ltd., to purchase the surplus gas from a large battery of Otto-Hilgenstock coke ovens about 1½ miles from the Dunston Station. Gas is carried to the station in 16-in. welded steel pipes and is burned under water-tube boilers. The station was originally laid out for four 6000-kw. units, only three of which were installed. The new installation consists of a 12,000-kw. turbo-alternator of the impulse reaction type, built by Richardsons, Westgarth & Co., Ltd., and Brown Boveri—the turbo and alternator, respectively. Merz & McClellan, of Newcastle-upon-Tyne and Westminster, are the consulting engineers.

Decision for Municipal Light Plant

Columbus, Ohio, has a municipal light plant which has been in operation for several years, and in the past few years has been selling some of its day output to private parties. A citizen, James M. Butler, sought from the courts an injunction against the city to prevent this practice, the case being outlined in the Jan. 20, 1914, issue of "Power." Since then the newly elected city solicitor, Henry L. Scarlett, has defended the city.

There were two main contentions made in support of the petition and amendment by plaintiff's counsel: (1) That the City of Columbus, by reason of the sale of current from its electric light plant to private consumers at less than cost is operating its plant at a loss, which loss must be paid by the taxpayers; and (2) that in the sale of such current there is no uniformity or classification of prices among customers. The operation of the plant by the city officials under these conditions was claimed to be such a gross and manifest abuse of their discretionary powers and such a disregard of the rights of the taxpayers as to amount to fraud upon them, entitling plaintiff as a taxpayer to an injunction..

The city solicitor argued in reply that an electric-light plant, such as is owned by the City of Columbus, is operated by the city acting in its proprietary capacity as distinguished from its governmental capacity. Thus the plant would be run as a business concern and, as such, might have pr..its and might have losses. The sale of electricity for private purposes so far has been incidental, in order to dispose of a portion of the day load, which otherwise was a waste product. The principal use of the plant being for lighting the streets and other public places, it is apparent that when the night load and a very small part of the day load are utilized on city properties the entire operation and maintenance cost, including interest and depreciation on the investment, is a burden upon the public. If the sale of the extra available day load to private consumers pays the extra operating cost incurred by its generation and a proper depreciation and interest charge on the extra equipment necessary for its generation and distribution, and contributes anything, however small, to the fixed charges, then the day load is sold at a benefit to the city and not at a loss.

Municipalities and their officers have the legal power, and it is their duty to apply the surplus power and use of all public utilities under their control for the benefit of their cities and citizens, provided always that such application does not materially impair the use of these facilities for the purpose for which they were primarily created.

As to its rates for private service, the city plant was in competition with a privately owned plant, and had to meet that competition as any business concern would. It did not have enough power to supply the whole city, and therefore furnished electricity to such customers as might use a sufficient quantity, in the judgment of the officers, to net the best returns. The contracts were entered into voluntarily by the private parties, and the rates made were agreed to and were satisfactory. No intimation was raised by the plaintiff that a higher price would have been secured, and so no foundation is laid for charge of fraud. No private consumer had sought court relief on the basis of unequal rates.

Judge Rodgers ruled against the plaintiff and in favor of the defendant, the city, and denied the injunction sought. Some quotations from his ruling are of wide interest, and are as follows:

I am unable to reach the conclusion that the pleadings make a case for injunctive relief, either on the ground of misapplication ot corporate funds, or abuse of corporate powers, or the execution or performance of contracts in contravention of the laws governing the city, or through fraudulent or corrupt procurement. The right of the city to furnish electric current to private consumers is conferred by statute wherein it grants the power to establish, maintain and operate municipal lighting, power and heating plants, and to furnish the municipality and the inhabitants thereof with light, power and heat, and to procure everything necessary therefor. And in the exercise of this power the city is exercising an administrative function. It is fundamental that, in the exercise of such duty, courts will not interfere unless the discretion of the officials is so grossly and manifestly abused as to amount to a fraud upon the taxpayers and a disregard of their rights.

Apparently, the theory of plaintiff's counsel is that, whatever service the city renders to one of its private citizens, it must be remunerative at least to an amount equal to the cost of the service. In other words, the service must be self-sustaining; otherwise it cannot be rendered by the city to the individual.

I do not understand that this is the theory upon which the various public utilities of a municipality are operated by it, such as the water-works, lighting and power plants, gas plants, garbage- and refuse-disposal plants, the removal of ashes and other refuse from the residences of its citizens and the like.

The statute granting authority to cities to furnish light and power to its inhabitants does not confer power on the city to sell electric light or power to the inhabitants, but confers power to furnish such light and power. Whether such light and power may be furnished above, at or below cost or even free to the inhabitants, does not appear by the express language of the statute. . . . The city is given power to furnish its citizens electric light and power, and it is left with the city to fix the terms upon which such light and power may be furnished. If the city sees fit to furnish light and power to its inhabitants at less than cost, I see nothing in the statute to prohibit the city, through its officials, from exercising its discretion to that end. If plantiff's contention were correct, that in the sale of electric current to the inhabitants there must be no loss to the city, and that the sale price must at least equal the entire cost of production, a municipal plant might never be able to furnish its citizens with electric light or power. Of necessity, every municipal plant of this character must start with a few customers; yet as a matter of economy must make preparation in the way of lands, buildings, installation of machinery, wiring, poles, and the like, for probable future increase of business. On the other hand, if the power conferred by the statute upon the city to furnish electric light and power to its inhabitants is construed to mean authority to sell at such prices as the city may determine, the city in the exercise of its proprietary functions is put in a position to operate the plant as business men would engage in a like enterprise. As a matter of economy business men would probably build their plant, not alone to supply present needs, but in anticipation of probable future demands, with the view that the future returns on the investment on account of increasing business would make up for any present losses.

The statutory authority of cities to furnish electric light and power to the inhabitants is found in the general enumeration of powers recited in the statutes, and these powers include the power to maintain police and fire departments, to provide for a supply of water, to establish, maintain and regulate free public band concerts and free public libraries, to provide for the renting of free public hospitals, to provide for the collection and disposal of sewage, garbage, ashes and animal and vegetable refuse, etc. For the use and benefit of its citizens the city charges them for some of the benefits above mentioned which the city has power to furnish, and for others it makes no charge whatever, as for example, the removal of garbage, ashes and refuse matter and the extinguishing of fires.

As it appears to me, so far as the city has the power to and is furnishing a part of its inhabitants electric current, who are willing to pay the price therefor, it is not within the province of the court to interfere with the prices at which the city is disposing of its electric current, merely on the ground that the city thereby is losing money.

A further contention is that the prices charged for the electric current are not uniform under the same or like conditions and are discriminatory among the city's customers. I am inclined to the opinion that the pleadings show a wrong in this respect that is in need of a remedy. That a city through its officials cannot discriminate in furnishing service of any kind to its citizens, but must act impartially in furnishing such service, appears to be fundamental. However, is the plaintiff a proper party to make complaint? The discrimination in rates charged and paid for the electric current in no wise appears to affect the plaintiff as a taxpayer. In other words, it is not shown that his taxes would be less if there were no discrimination in rates, or in fact would be affected either way; nor does it appear that he has sought to have the city furnish him service at a reasonable rate, and it has been refused, although the city is furnishing like service to others on more favorable terms. In this view of the case I am of the opinion that the plaintiff does not allege sufficient facts in the respect just mentioned to entitle him to injunctive relief.

Rate Publicity Ordered

One of the most far-reaching orders that the upstate Public Service Commission of New York has issued in years went into effect Feb. 15, requiring the rate schedules of all gas and electric corporations and all municipalities subject to the regulation of the commission to be filed in the commission's office, and to be kept in convenient form for the inspection of customers at all offices of such corporations and municipalities where contracts for service are made or payment for services received.

This order follows out the plan of the commission in regulating other corporations under its control, and requiring the fullest publicity of all rate schedules in order to prevent discrimination. The order specifies that the rate schedules are to be uniformly printed and that when asked for by a customer the person having charge of them in the corporation's office shall give all necessary assistance in gaining information therefrom. The schedules include not only rates, present or proposed, but regulations for service and privileges and facilities under each rate.

The Corrosion of Condenser Tubes

We have received from E. Bates, White Bay Power House, Sydney, N. S. W., a copy of a paper on the corrosion of condenser tubes, read by him before the Electrical Association of New South Wales in 1913. In this paper Mr. Bates states that the exceedingly serious corrosion of condenser tubes experienced at the Ultimo power station of the Sydney Tramways had been completely checked by the simple procedure of painting the whole of the interior of the cast-iron water boxes with an anticorrosive paint. Following the success at Ultimo, the same procedure was adopted with equally good results at the power station of the Adelaide Tramways, where much trouble had been experienced from condenser-tube corrosion. Attempts to check this by improving the contact between tubes and tube-plate and by suspending zinc plates in the water boxes had all failed, but on learning of the results achieved by Mr. Bates at Sydney, it was decided to try the same plan at Adelaide. In the first instance, the interior of the water boxes, covers and pipes of one condenser were painted with three coats of biturine solution. The result was that the corrosion did not recommence until the paint was washed off. Subsequently an anticorrosive paint was used, and was found to last three times as long as the biturine solution.

As is well known, many engineers have made claims to success in stopping condenser-tube corrosion, but in many cases an extended trial has proved these pretensions to be illusory. An example brought forward at the discussion on Mr. Bates' paper was one presented at the Ithaca meeting of the American Association for the Advancement of Science in 1906, by W. W. Churchill, who declared that tube corrosion at the Bay Ridge station of the Brooklyn Edison Co. had been traced to stray currents and that the trouble had been completely checked by installing a booster to provide a counter electromotive force. One of the speakers on Mr. Bates' paper related, however, that he had visited New York subsequently and learned that the plan in question had proved a complete failure, and that the booster sets providing the counter electromotive force had been thrown out of service. It is therefore interesting to learn from Mr. Bates that his system is still in use at the Sydney power stations, and with excellent results.

The trouble originally arose with the condensers of certain 5000-kw. turbo-generators. Electrolytic methods of protection were tried on the installation of a new unit, and for eight months this condenser gave no trouble and electrolytic protection was deemed a success. Then, however, the tubes began to fail rapidly. It was therefore decided to try Mr. Bates' plan on two of the older condensers, and when it proved successful with them, the same process was adopted in the case of the new condenser, the electrolytic protection being dispensed with. During the succeeding nine months not a tube failed in this condenser.

Mr. Bates' method is based on the hypothesis that the corrosion, being of the pit-hole type and practically confined to the bottom of the tubes, must be due to the deposit of electro-negative material, and this material must, he concluded, have been derived from the corrosion of the cast-iron water boxes. He states that once a pit hole is started by the deposit of such material, the corrosion will proceed even if the initiating cause be washed away subsequently, since when local corrosion has commenced the "balance" of the alloy is upset. The ordinary condenser tube has, he says, a composition giving a minimum waste by corrosion in normal conditions. If the constitution is altered locally by selective dissolution following the deposit of electro-negative matter, then, even when the latter is removed, the corrosion will continue, owing to the "balance" of the alloy having been disturbed.

During the 15 months which have elapsed since Mr. Bates' paper was read the number of tubes removed from the two older 5000-kw. condensers has, he informs us, not exceeded three per month, while before the Bates method of protection was adopted it was not uncommon to lose 150 tubes from one condenser in a single week.—"Engineering."

Recent Court Decisions

Digested by A. L. H. STREET

Damages Caused By Power Dam—A hydro-electric power company is liable to a suit in a county into which its dam backs water to the injury of inhabitants of that county, although its principal place of business and its plant may be in other counties, according to the decision of the Georgia Supreme Court in the case of Central Georgia Power Co. vs. Stubbs, 80 "Southeastern Reporter" 636. The court decided these further propositions: The Georgia statute, which permits suit to be brought in the county where the cause of action arose, is not unconstitutional. If water is so impounded by the dam as to create a nuisance, to the injury of an adjoining landowner, he may recover damages, including those brought about by sickness of himself and family caused by the nuisance, but, the conditions complained of being permanent, he must recover all of his damages in one suit, not being entitled to prosecute successive actions for continuing injury. The power company is not liable for loss of trade at his mill resulting from people moving away on account of the nuisance.

Insurance of Boilers—A peculiar case involving the liability of a fire-insurance company on an ordinary fire-insurance policy for injury to a stationary boiler was recently passed upon by the Kansas Supreme Court. It appears that at the close of a business day the boiler was left more than half full of water, with the gas which furnished the fuel turned off. The next morning it was found that someone had entered the building and caused the fire to be restarted and kept up long enough after the water was exhausted in steam or by draining to injure the boiler. The next morning the gas was found turned off. On these facts the Supreme Court decided (McGraw vs. Home Insurance Co., 144 "Pacific Reporter," 821) that the evidence was insufficient to warrant the inference that someone not connected with the plant had maliciously caused the injury, so as to render the insurance company liable for the loss. The court holds that proof of the facts stated was not inconsistent with the injury having been caused by someone connected with the plant, in which case the insurance company could not be held on the policy.

Responsibility for Boiler Explosion—In lately affirming judgment against the defendant in the case of Eberts vs. Mount Clemens Sugar Co. (148 "Northwestern Reporter," 810) for injuries sustained by the plaintiff, an employee of the defendant, in a boiler explosion, the Michigan Supreme Court held that an employer's duty to make proper inspection of boilers to promote the safety of employees cannot be discharged by merely entrusting it to a certain employee. In other words, an employer is liable for injury directly attributable to the negligent omission to discover any defective condition of a boiler, although the immediate act of carelessness may have been that of a co-employee of the injured worker to whom the duty of inspection was entrusted. In this case it was the plaintiff's theory that the rear stay-plate of the boiler became bulged or corrugated by overheating, that this was a dangerous condition likely to result in a failure or explosion, and that an inspection, which was negligently omitted, would have disclosed such condition. On the other hand, the defendant claimed that the condition could not have been discovered by a reasonable inspection before the accident and that the initial rupture occurred not in the stay-plate, but in the combustion chamber.

OBITUARY

H. WARD LEONARD

H. Ward Leonard, the well known electrical engineer, died suddenly at the Hotel Astor, New York, on Feb. 18, while attending the annual banquet of the American Institute of Electrical Engineers. He was born in Cincinnati, Feb. 8, 1861, was graduated from the Massachusetts Institute of Technology at the age of 22, and a year later became associated with Mr. Edison in the introduction of the central-station business. After three years in this line he was with the Western Electric Light Co. for a short period, and later became part of the firm of Leonard & Izard. This concern was finally absorbed by the Edison company, and Mr. Leonard became general manager of the combined Edison interests.

In connection with the Ward Leonard Electric Co., which he founded, his later life was identified with a large number of important inventions, among which are the Ward Leonard system of motor control, used generally by the U. S. Navy; the well known multiple-voltage system which bears his name, a lighting system for trains and automobiles, and an electric gear shift, besides other inventions relating to mine hoists, electrically driven reversible rolling mills, locomotives, elevators and gasoline-electric trucks. In 1903 he was awarded the John Scott medal by the Franklin Institute, and also received medals at both the Paris and the St. Louis Expositions. He was a life member of the American Institute of Electrical Engineers. A widow survives him.

ENGINEERING AFFAIRS

The Irish-American Association of Stationary Engineers is the newest organization in this craft. It meets at K. of C. Hall, 81 Hanson Pl., Brooklyn. Harry F. Burns, at the same address, is president.

National District Heating Association—The next annual convention will be held in Chicago, June 1, 2 and 3, 1915, with headquarters at the Hotel Sherman. The papers will be: "Commercial End of the Heating Business," by C. F. Oehlman, of the Denver Gas & Electric Co., Denver, Colo.; "Typical Hot Water Heating Plant," by W. G. Carlton, New York City; "A Pressure Study Survey," by C. C. Wilcox, of Commonwealth Power Co., Jackson, Mich.; "Exhaust Steam vs. Live Steam for Heating," G. W. Martin, New York City; and a paper, the title of which is not yet announced, by E. F. Tweedy, of the New York Edison Co. Reports will be made by the committees on rates, underground construction, public policy, education, meters, station operating and station records. In addition, there will be three addresses by men of national reputation. Altogether, the next convention promises to exceed in attendance and interest any that the association has ever held.

NEW PUBLICATIONS

PRACTICAL IRRIGATION AND PUMPING. By Burton P. Fleming. Published by John Wiley & Sons, New York, 1915. Size 6x9 inches; 260 pages; cloth. Price, $2.

According to the author, the farmer is now looking toward the vast areas on the higher ranges, or mesas, where the latent agricultural possibilities of the soil are enormous. To irrigate this land means the pumping of surface and subsurface water, and it is the purpose of this book to treat chiefly of the subject of pumping. The author considers the matter of wells and well sinking, pumps, pumping machinery, selection of prime movers for pumps, and irrigation by windmill-operated pumps. The chapter on pumping costs should prove interesting to those interested in irrigation. Contractors and engineers, who are called on in their professional capacity to solve the pumping difficulties of irrigation jobs, should find the book of value.

HANDBOOK OF FORMULAS AND TABLES FOR ENGINEERS. By Clarence A. Pierce, instructor in power engineering in Sibley College, Cornell University. With mathematical sections by Walter B. Carver, assistant professor of mathematics, Cornell University. Published by the McGraw-Hill Book Co., New York. Flexible leather; 168 pages; thin paper; tables and diagrams. Price, $1.50.

This book is a compendium of tables and formulas frequently used by students and practicing engineers in making calculations in higher mathematics, mechanics and machine design, and should be found of great convenience to those who may have forgotten or are doubtful of some of the applications of higher mathematics in the solution of engineering problems.

The work is divided into 10 principal sections, covering the subjects of algebra, geometry and trigonometry, analytical geometry, calculus, measurements, physical and chemical properties of substances, mechanics, strength of materials, standard gages, fastenings and flanges, and mathematical tables. It also gives a Mollier entropy chart of the thermal properties of steam. The book affords in convenient form a collection of tables and formulas most commonly used by engineers and for which they have usually been dependent upon reference to a number of handbooks and textbooks.

BUSINESS ITEMS

The Lea-Courtenay Co., 90 West St., New York, due to increased business, has opened its own Chicago branch in the Conway Building, with Mr. Maher, formerly of the Maher & Byrne Co., as manager.

The Whitlock Coil Pipe Co., Hartford, Conn., has just published Bulletin No. 22, Series No. 3, dealing with the subject of heating surfaces in steam actuated water heaters. Copies are mailed on request.

The Schaeffer & Budenberg Mfg. Co., in order to take care of its increasing business, has moved its offices and plant to the splendid new building at South Fifth and Berry St., Williamsburg, Brooklyn, N. Y.

"Central Power Station Economy" is the title of a very interesting booklet published by the Wm. B. Scaife & Sons Co., Pittsburgh, Penn. It is a treatise on water purification for all purposes. Copies are mailed for the asking.

The Combustion Engineering Corporation, 11 Broadway, New York, has just issued a new booklet descriptive of the type "E" stoker. It is a 20-page booklet, well illustrated, giving a complete description of the stoker, construction and operation and showing several installations. Copies are mailed on request.

William B. Merrill & Co., 3368 Washington St., Boston, Mass., has received order to furnish "Tripp" metallic packing for all piston rods and valve stems of the new steamer now being built for the New York & Porto Rico Steamship Line. The company has also received during the past month orders for 234 sets of "Tripp" metallic packing from Ingersoll-Rand Co.

CONTRACTS TO BE LET

Bids received until Mar. 12, 1915.

Five Pumping Engines

MAYFAIR PUMPING STATION.

Department of Public Works.

Chicago, February 17, 1915.

Sealed Proposals will be received by the City of Chicago until 11 A.M. Friday, March 12th, 1915, at Room 406 City Hall, and then publicly opened, for furnishing and erecting five pumping engines at the Mayfair pumping station, Chicago, as follows:

Three pumping engines, capacity 25 million gallons per day, normal head 140 ft.

Two pumping engines, capacity 17½ million gallons per day, normal head 200 ft.

The contract includes discharge piping and suction connections for seven engines, according to Plans and Specifications on file in the office of the Department of Public Works of said City, Room 406 City Hall.

Proposals must be made out upon blanks furnished at said office, and be addressed to said Department, indorsed "Proposals for Five Pumping Engines, Mayfair Pumping Station," and be accompanied with Twenty-five Thousand Dollars in money or a certified check for the same amount on some responsible Bank located and doing business in the City of Chicago and made payable to the order of the Commissioner of Public Works.

The Commissioner of Public Works reserves the right to reject any or all bids.

A deposit of three hundred dollars ($300.00) will be required to insure return of plans and specifications.

No proposal will be considered unless the party offering it shall furnish evidence satisfactory to the Commissioner of Public Works of his ability, and that he has the necessary facilities together with sufficient pecuniary resources to fulfill the conditions of the Contract and Specifications, provided such Contract should be awarded to him.

Companies or firms bidding will give the individual names as well as the name of the firm with their address.

L. E. McGANN,
Commissioner of Public Works.

POWER

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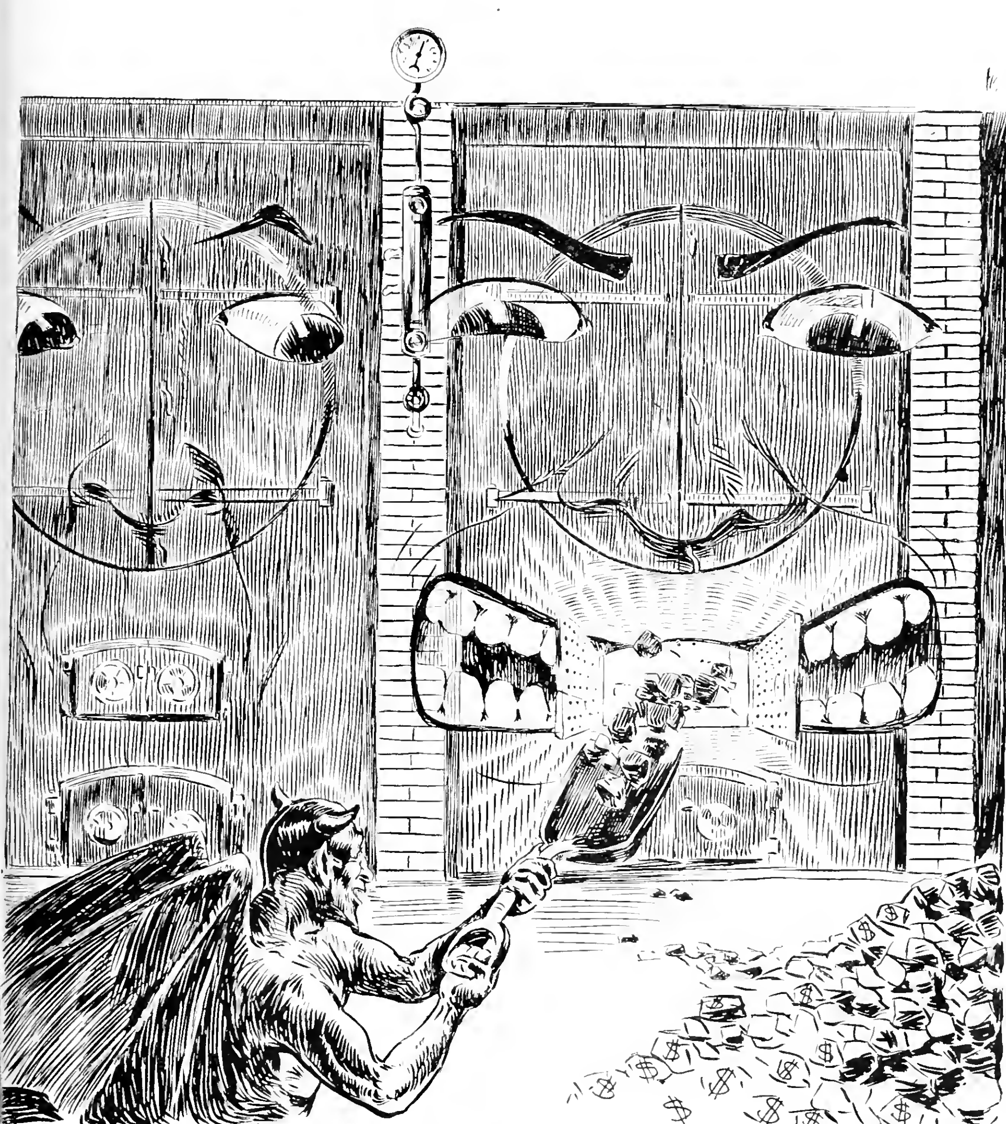


How the Employer Thinks of the Fireman

Extension of the Cos Cob Plant

By Warren O. Rogers

SYNOPSIS—The chief features of the station equipment are water-tube boilers having superheating coils, and eight steam turbines consisting of three 3750-kv.-a., four 5000-kv.-a. and one 4250-kv.-a. units; a combined forced- and natural-draft system is operated with the new boilers, the forced-draft fans being turbine driven and the first to operate with a reducing gear between the fan and turbine.

It is doubtful if any steam-power plant in this country operates with so much depending on continuity of service as the one at Cos Cob, Conn., which supplies electrical energy to the New York, New Haven & Hartford R.R.

When the Cos Cob plant was first built and the New Haven system was electrified as far as Stamford, Conn., 11,000 volts, single-phase, was the working voltage of the generators and on the lines. The voltage was supplied from the generator terminals to the contact wires without the aid of transformers. As this was a departure from existing practice, new problems and difficulties, naturally, were introduced, but the system was developed and the difficulties were overcome with two exceptions. One was that of electro-magnetic disturbances in neighboring telegraph and telephone circuits paralleling the railroad tracks. This disturbance had been corrected in a measure, but with the necessity of using larger currents as traffic increased, the adding of neutralizing transformers and other corrective apparatus did not appear satisfactory.

The other need was in relation to transmission voltages, and as it was planned to extend the electrification of the New Haven lines to New Haven, a distance of 45 miles, as well as to take on the Harlem River branch and freight yards, it was necessary to add to the original plant the turbines and boilers required to carry the increased load. There were difficulties in the way of raising the transmission voltage, because about 350 miles of overhead-contact wire insulation, together with rolling stock and other apparatus, would require replacing.

Under the old system all of the current flowing in either the overhead wire, the rails or ground return was in the same direction for the greater part of the trackage involved. With the new arrangement the generators at the power house do not directly feed the contact wire, but are connected to 22,000-volt auto-transformers at the power house, which have their centers grounded to the rails; the terminal voltage of the generators is, as formerly, 11,000 volts. One terminal of the transformer is carried to the contact wire and the other to feeder wires.

Turbine Plant

Two views of the turbine room are shown in Fig. 1, in which there are eight horizontal steam turbines with a total rated capacity of 35,500 kv.-a.; single-phase, 25-cycle current is used for railroad electrification, but three-phase for the other transmission.

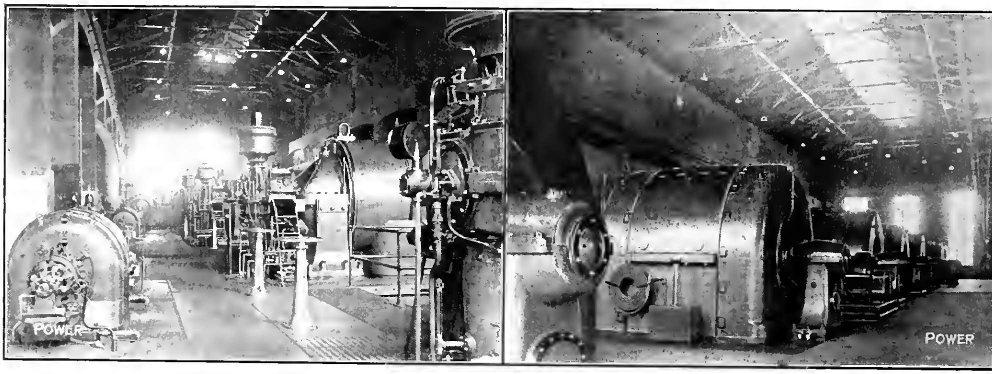


Fig. 1. Two Views of the Cos Cob Turbine Room

The turbines of the old station are connected to surface condensers having engine-driven circulating and independent air pumps. The four new turbines exhaust into jet condensers. Fig. 2 shows an elevation of the piping and arrangement of the condensers in the basement. Fig. 3 is a side elevation of the new boiler room.

Exciter current is furnished for the generators in the old plant by two 12 and 22 by 13-in. compound-vertical engines, each directly driving a 125-kw., 125-volt, direct-current generator. For the new units there are two turbine-driven, 125-kw., 125-volt generators driven through a reducing gear from one turbine. There is also one 125-kw., 125-volt generator driven by a 190-hp., 440-volt induction motor at 480 r.p.m. and one 175-kw., 125-volt generator driven by a 260-hp., 440-volt induction motor at 480 r.p.m.

Along one side of the turbine room are two turbo-generators of 130-kw. capacity, each delivering 2300-volt, single-phase, 60-cycle alternating current at 3600 r.p.m. The electrical energy developed by these units and from a motor-driven set consisting of a 500-hp., 440-volt induction motor and a 450-kv.-a., 2300-volt alternating current, three-phase, 60-cycle generator at 720 r.p.m., is for operating railway signals. The plan view, Fig. 4, shows the location of the various units in the new half of the plant. There is a noticeable absence of piping in the

fan placed above the boilers and between the economizers and the stack. The furnace gases from eight boilers pass through two economizers and those of the other six pass through but one before going to the fan and stack.

In the boiler-room addition there are 14 water-tube

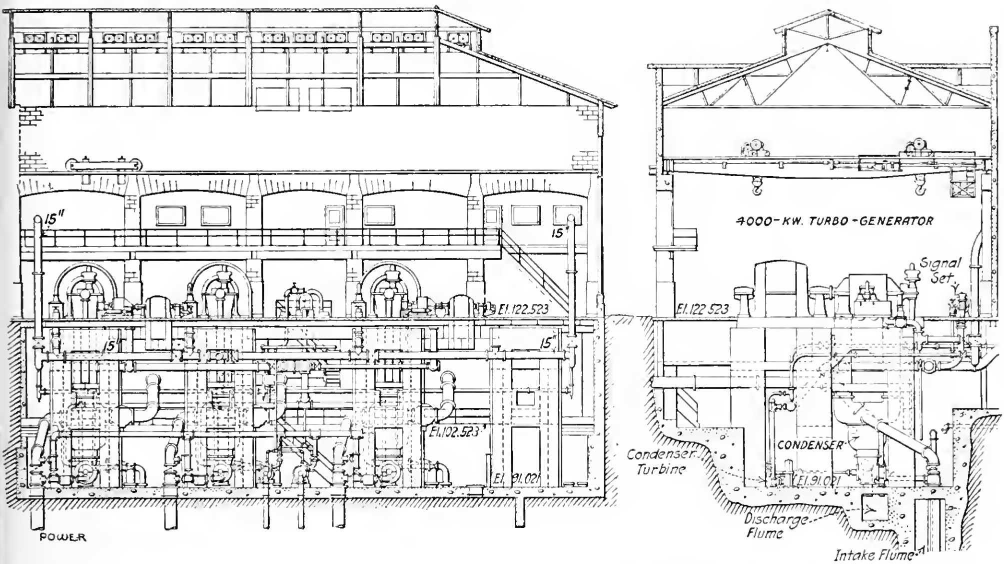


FIG. 2. SIDE AND END ELEVATION OF TURBINE AND CONDENSER ROOMS

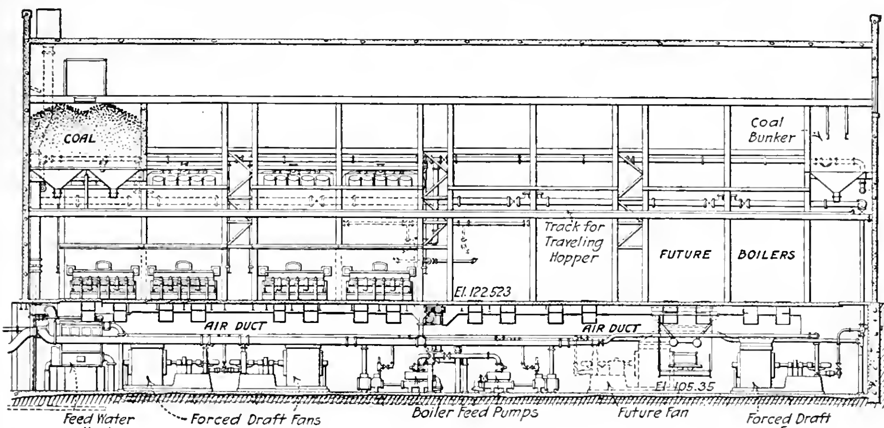


FIG. 3. SIDE ELEVATION OF THE NEW BOILER ROOM

urbine room and but little in the boiler rooms; most of he pipe lines are in the basement.

BOILER ROOMS

In the old boiler room, Fig. 5, there are 14 three-drum vater-tube boilers, each having 5200 sq.ft. of heating surace. The furnaces are fitted with mechanical stokers. The boilers are arranged two in a battery, with eight on ne side and six on the other side of the boiler room. Each furnace is supplied with induced draft by a single

boilers (Fig. 6), each having 6250 sq.ft. of heating surface. The tubes are 14 and 18 ft. in length and $3\frac{1}{4}$ in. in diameter. These boilers are of the counter-current type, the hottest water meeting the hottest gases and the coldest water meeting the coldest gases. The direct heating surface, or that in contact with the radiant heat of the furnaces, is 12 per cent. of the total heating surface, or 750 sq.ft.

The boilers are equipped with superheaters, which superheat the steam 100 deg. F. Each boiler furnace is fitted

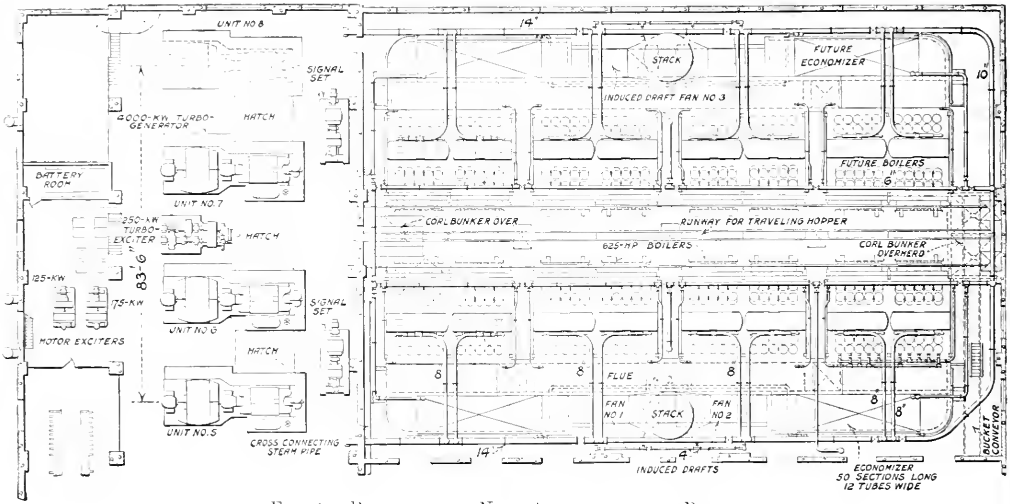


FIG. 4. PLAN OF THE NEW SECTION OF THE PLANT

with a seven-retort underfeed stoker driven by the induced-draft fan turbine. A combination forced- and induced-draft system is used. There are three double-inlet, up-blast, forced-draft, turbine-driven fans (Fig. 7) in the pump room, which is under the firing aisle of the boiler room. Each fan is 42 in. in diameter and delivers 100,000 cu.ft. per min. at 50 deg. F., against a resistance of 5 in. of water. This would require 190 hp. per fan at a fan speed of 510 r.p.m. The turbines run noncondensing at 2040 r.p.m., against a back pressure of about two pounds. Each has sufficient capacity to supply about twenty-five horsepower more than is required by the fan, for the purpose of driving stoker mechanism. Under normal operating conditions but two of the three fans are in operation, and the capacity required of them with the boilers running at 200 per cent. rating will be 95,000 cu.ft. per min. per fan. At this load the maintained resistance is figured to be only 4 in., but 5 is supplied to be on the safe side.

The speed of the fans is governed by the boiler pressure, 200 lb., 100 deg. superheat, acting on a regulating valve which controls the steam supply to the turbines. The difference in speed between the turbine and fan is due to a set of 4 to 1 reduction gears composed of a pair of double-helicoidal gears and flexible couplings, Fig. 8. As the stokers are driven by a series of chain drives, the feeding of the stokers and the speed of the fans are regulated by the steam pressure and operate in unison. The position of the fans is shown in Fig. 3. Space has been provided for a future fan outfit.

At the back of each row of boilers, and between them and the economizers, is a main smoke flue, 6 ft. 9 in. wide and 10 ft. 6 in. high. One flue connects with two economizers, which receive gases from eight boilers. On the opposite side of the boiler room the smoke flue of six boilers connects to a single economizer of the same size as the others.

The induced-draft fans, of which there are two for each row of boilers, are placed between the economizers and the $12\frac{1}{2}$-ft. diameter metal stack. The general arrangement and a plan view of the boiler room are shown in Fig. 4. One of the engine-driven fans is shown in Fig. 9. Each of the four fans is designed to handle 140,000 cu.in. of gas at 500 deg. F., against $1\frac{3}{4}$-in. suction.

FIG. 5. OLD BOILER ROOM

FIG. 6. NEW BOILER ROOM

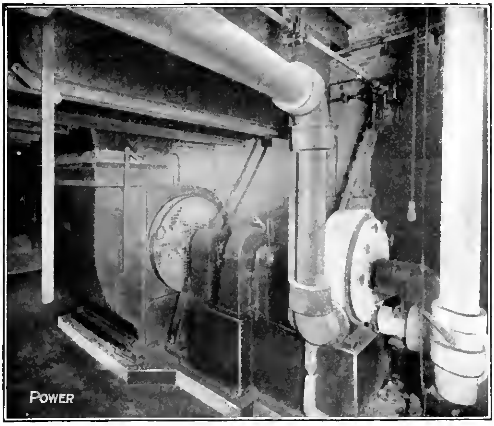


Fig. 7. Turbo-Driven Forced-Draft Fan

The normal volume of air handled is considerably less than that mentioned. The fans are on the ground floor of the boiler room. Their bearings are water-cooled.

As there are three economizers used in connection with the 14 boilers, the average is 8330 sq.ft. of boiler heating surface to one economizer. The boiler pressure being approximately 200 lb., the economizers carry about 50 lb. greater pressure. Each economizer has 624 pipes in 52 sections, each 12 pipes wide. The pipes are 10 ft. long between headers and are arranged in staggered rows. In the other boiler room there are also three economizers of 52 sections, 10 tubes in each.

The damper arrangement is such that if any battery of two boilers be cut out of service, the gases from the others will still go to the economizer. In case it is desirable either or all economizers can be cut out and the furnace gases bypassed to the stack. Although there are two fans for six boilers, on one side of each boiler room space has been reserved for another economizer and two additional boilers.

Pumps

In both the new and the old boiler plants the pump room is in the boiler-house basement. Figs. 10 and 11 show a view of each. In the old pump room there are three 12&20x12x18-in. duplex pot-valve, boiler-feed pumps which supply the turbine glands with water. In the new pump room there are two boiler-feed pumps of the same size as the others, and two 8x8x18-in. duplex pumps for supplying gland water to the turbines.

Fuel Supply

There are two sources of coal supply—by rail and by water. Barring delays, the fuel is delivered in barges to a wharf, hoisted by a clam-shell bucket and discharged into a coal crusher, from which it is loaded into two 2½-ton cable-drawn cars. These cars are hauled up the single-track runway, Fig. 12, and discharge the coal into the bins at the turbine-room end of the boiler house. At the opposite end of each boiler room is a second bin, supplied from cars which discharge into an underground hopper and crusher from which the coal is elevated to the bins by a bucket conveyor.

In case there is no available coal supply from the railroad, the bunkers can be filled by loading the 5-ton larry car used ordinarily to supply the stokers from the other coal bunkers and discharging its contents into a chute leading to a hopper above the conveyor. Thus, the supply of coal in the bin not reached by cable cars is maintained. An ingenious track arrangement permits of the cable cars passing at a turnout on the runway. This is made possible by the use of outside- and inside-flanged carwheels. A glance at Fig. 13 shows how the cars take the rails. One car has the inside-flanged wheels

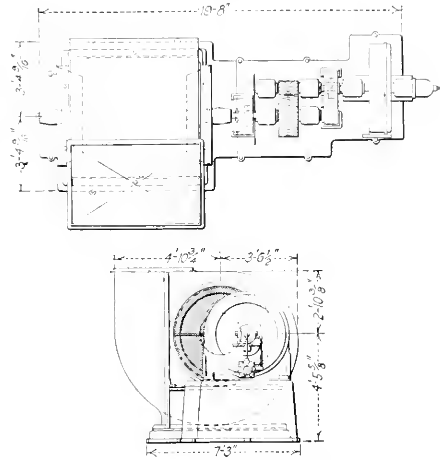


Fig. 8. Diagram of Fan Unit

and the other car outside flanges. Fig. 12 shows the cars about to pass at the turnout. This arrangement requires but a single track and reduces the construction cost of the trestle.

From the bins the coal is discharged into the larry scales, where it is weighed and then run along the track

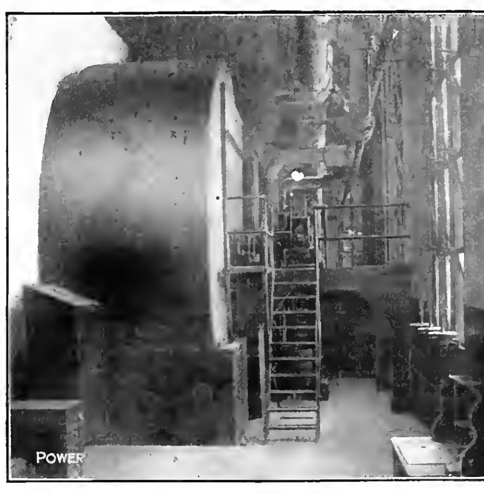


Fig. 9. Engine-Driven Induced-Draft Fan

above the stoker hoppers. Five men handle all the coal consumed in the plant. Two are at the hoisting tower, one above the coal bunkers and one man in both boiler rooms to handle the barney cars.

Ashes from each stoker fall into a brick-lined hopper under which a car is run to receive its load, which is drawn out into the yard by a small storage-battery locomotive and dumped for filling-in purposes.

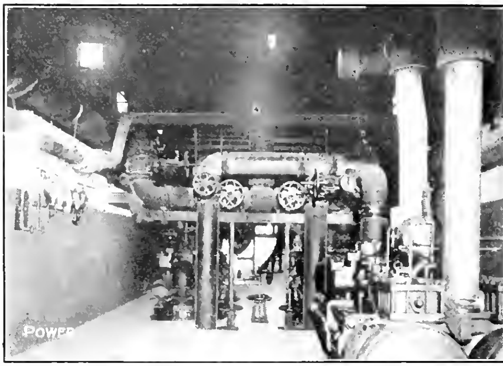


Fig. 10. New Pump Room

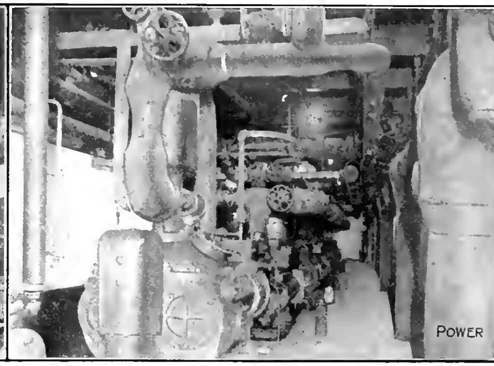


Fig. 11. Old Pump Room

Piping

An end elevation of the new boiler room is shown in Fig. 14, which with Fig. 4 presents the details. Each boiler is connected by an 8-in. branch pipe to the main 10-in. header. The header is constructed on the loop plan and so valved that any two boilers and their section of header may be cut out of service without interfering with any other units. The headers back of the two rows of boilers drop to a 15-in. cross header in the turbine-room basement. From this a 10-in. lead is run to each of the new turbines. This piping is shown in Fig. 2.

The 6-in. auxiliary header has three sources of steam supply. It is also designed on the loop plan, tapping off from each of the 15-in. vertical header pipes and also from the 10-in. end of the main steam loop in the boiler house. The auxiliary steam line supplies the condenser turbines through 3-in. pipes. The exciter turbine receives its steam supply through a 4-in. pipe connecting with that section of the 6-in. header running to the pump room and connecting the main steam line at the loop end. A study of the piping scheme shows its simplicity, although provision has been taken to insure continuity of service.

While the addition to the plant is practically a separate power plant in itself as applied to the steam end, the new boiler room is connected to the old by a 10-in. cross connection, which is connected with the 15-in. cross-feeder in the turbine basement.

The 10,000-hp. feed-water heater for each boiler plant is in the basement and is piped to the boiler feed-water pumps by a 12-in. pipe having a 7-in. branch pipe to each pump, which discharges into a 9-in. main connecting with the economizers. From the economizers the 9-in. feed line forms a loop along the front of the boiler and supplies them through 3½-in. branch lines.

All boiler blowoff pipes are in a tunnel under the main smoke flue. The blowoff main for the economizer is also in this tunnel.

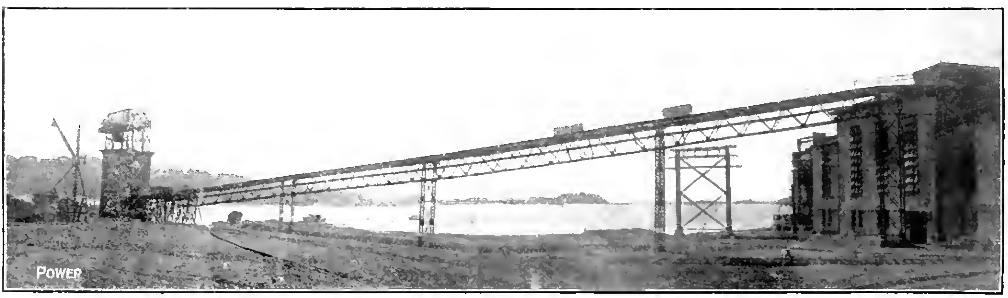


Fig. 12. Single-Track Runway Using Double-Car Service

As in most large power plants, the pipe lines are designated by colors. In the Cos Cob plant the pipe-line color scheme is as follows: White—high-pressure steam lines; red—Holly return system; yellow—auxiliary exhaust and all low-pressure drips; black—boiler-feed lines; blue—all water pipes other than feed and fire pipes; gray—fire protection; dark green—air pipes; light green—crank-case oil piping; pink—cylinder oil piping; brass, no paint—turbine oil piping.

As is now the general practice in modern power plants, all of the electrical-control apparatus is at one side of the turbine room. A gallery runs the length of the building and at one end is the chief engineer's private office, the general office and switchboard room (Fig. 15). On the same level are the remote-control oil switches (Fig. 16). Below, in suitable compartments, are the duplicate busbars. At the back of the station, a general view of which is shown in Fig. 17, is a transformer house in which are six 7200-kv.-a. auto-transformers, which raise the voltage from 11,000 to 22,000 volts, the center point of the transformers being connected to the rails.

Fig. 18 is a diagram of the present system of distribution. Line auto-transformers are arranged along the track and are similarly connected for reducing the voltage to 11,000 for the locomotives. The center terminal of the outdoor transformers is connected to the rails, one terminal to the contact wire and the other to the feeder wire. This arrangement breaks the line into short lengths. Reference to Fig. 18 shows that a train draws its current from the transformers on either side of it. If the train is midway between transformers half of the current will complete its circuit through the rails and ground in one direction, and the other half through the rails and ground in the other. When the train is nearer to one transformer than another it will receive the greater part of its current from the nearest one and the smaller part from the distant transformer. Thus the current supply balances regardless of which transformer the larger amount is taken from.

The changes from the old to the new system were considerable, because the transition had to be made without interfering with the operation of the train service, making necessary many temporary connections and the perfecting of details which would allow of a rapid and easy change-over when the final connections were made.

When it is considered that about 350 miles of track is electrified it is seen that it was important that each man along the line should know what to do and when to do it. At some points the changes consisted of merely disconnecting a few wires, and at others many changes were necessary. As the final work was done at night, team

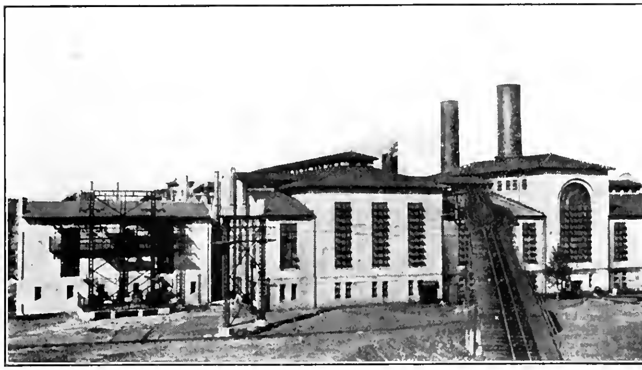


Fig. 13. Track and Turnout Arrangement for Cable-Drawn Cars

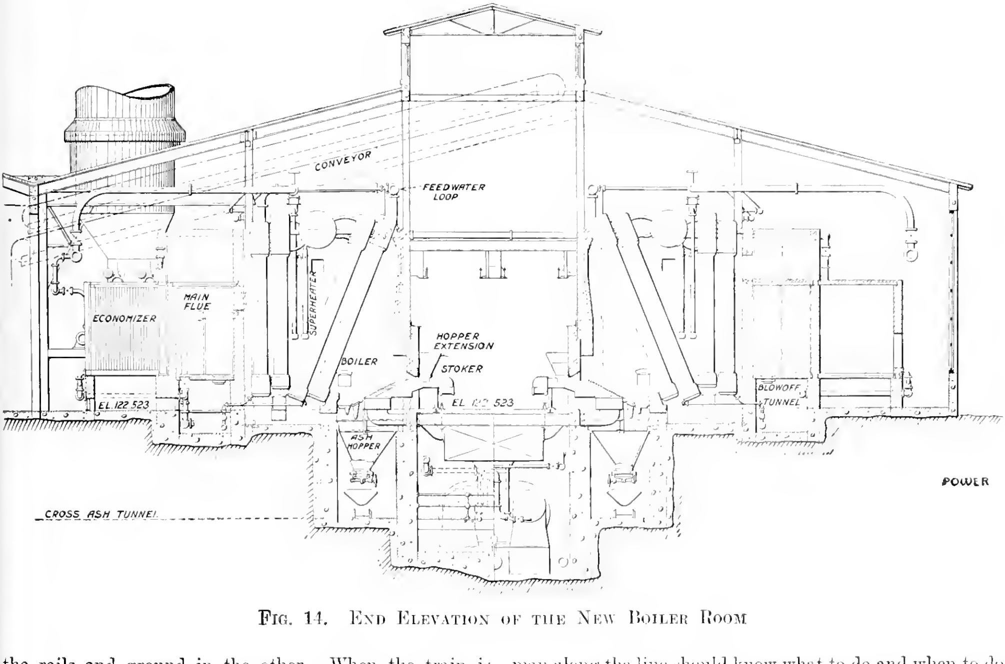


Fig. 14. End Elevation of the New Boiler Room

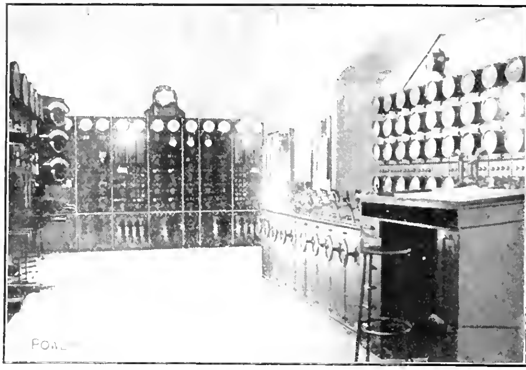


FIG. 15. CONTROL ROOM WITH SWITCH AND BENCH BOARDS

FIG. 16. AISLE BETWEEN REMOTELY CONTROLLED OIL SWITCHES

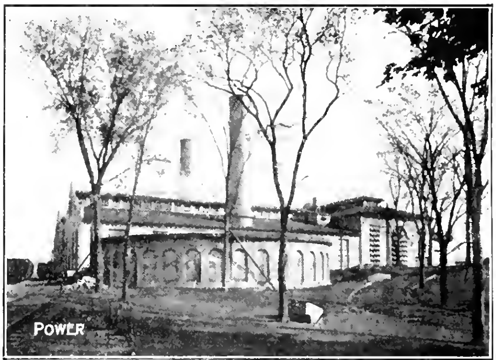


FIG. 17. GENERAL VIEW OF THE STATION

work of the highest order was imperative and a mistake would mean delay.

But four hours, from 2 to 6 a.m., were available for the final change-over. At 2 o'clock the power plant was shut down, and all concerned were notified. Within two minutes the load dispatcher received the first "ready" report. This was quickly followed by others and within 70 minutes from the start the last report was in and all work on 350 miles of track had been finished.

The power-house changes required longer, but at 3:21 a.m. the plant was ready to start up under the new system. At 4:45 a.m. every part of the system was reported ready for service and at 5:25 the first train received current by the new system. At 5:31 the operating department was advised that full normal service might be resumed.

The entire work of addition and reconstruction of both the power plant and lines as herein described was per-

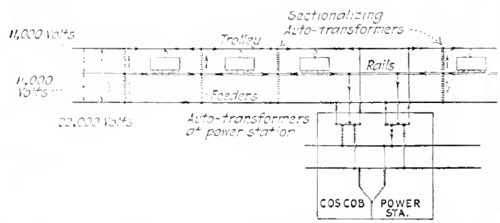


FIG. 18. DIAGRAM OF THE NEW SYSTEM OF ELECTRIFICATION

formed by the Engineering Department of the New York, New Haven & Hartford R.R., and the plans for the entire work were prepared by Westinghouse Church Kerr & Co., to whom the author is indebted for line drawings of the power-plant addition.

PRINCIPAL EQUIPMENT OF THE COS COB POWER PLANT ADDITION

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Turbo-generators	Horizontal	5000-kv.-a	Main units	180 lb. steam, 100 deg. superheat, 1500 r.p.m., 1-phase, 25-cycle, 11,000 volt	Westinghouse Companies
4	Condensers	Leblanc, jet	No. 19	With 5000-kw. turbines	28-28½-in. vacuum	Westinghouse Machine Co.
4	Turbines	Single-stage		Condenser pump drive	180 lb. steam, 100 deg. superheat, 680 r.p.m.	Westinghouse Machine Co.
1	Turbine	Horizontal	125-kw	Driving exciter generator	180 lb. steam, 100 deg. superheat	De Laval Steam Turbine Co.
2	Generators	Direct-current	125-kw	Exciting main generators	750 r.p.m., 125 volts	Westinghouse Electric & Mfg. Co.
2	Motors	Induction	190-kw	Driving exciters	480 r.p.m., 440 volts	Westinghouse Electric & Mfg. Co.
2	Generators	Direct-current	125-kw	Exciting main generators	480 r.p.m., 125 volts	Westinghouse Electric & Mfg. Co.
2	Turbo-generators	Horizontal	130-kw	Signal service	3600 r.p.m., 2300 volts, single-phase, 60 cycles	Westinghouse Companies
1	Motor-generator	Direct-connected	500-hp., 450-kv.-a	Signal service	720 r.p.m., 2300 volts, three-phase, 60 cycles	Westinghouse Electric & Mfg. Co.
14	Boilers	Bigelow-Hornsby	6250 sq.ft. heating surface	Steam generators	180 lb. steam, forced and induced draft	Bigelow Co.
14	Stokers	Taylor	Seven-retort	With main boilers	Driven by forced-draft turbines	American Engineering Co.
14	Superheaters	Foster		With main boilers	100 deg. superheat	Power Specialty Co.
3	Turbines	Single-stage	215-hp	Driving 12-in. fans	180 lb. steam, variable-speed	De Laval Steam Turbine Co.
3	Fans	Up-blast-multivane	12-in.	Forced-draft	Turbine-driven, with reduction gears	B. F. Sturtevant Co.
3	Engines	Slide-valve		Driving induced-draft fans	180 lb. steam, variable-speed	Skinner Engine Co.
3	Fans	Encased	12-ft. diameter	Induced-draft	Engine-driven, variable-speed	B. F. Sturtevant Co.
3	Economizers	Sturtevant	833 sq.ft. heating surface	With Bigelow boilers	With flue gases	B. F. Sturtevant Co.
2	Pumps	Duplex-pot-valve	12&20x12x18-in.	Boiler feed	Automatically controlled	Warren Steam Pump Co.
2	Pumps	Duplex	8x8x18-in.	Water to gland on turbines	Constant-speed, automatically controlled	Wilson-Snyder Mfg. Co.

Maintaining High Insulation Resistance

By H. M. McLellan

Where electrical machinery is subjected to fumes, as sometimes when located in gas-engine stations or near chemical plants, it is necessary that special precautions be taken to insure the insulation resistance being maintained at a high value. Deposits of carbon and copper dust, dirt, or chemicals will often be found on the windings of apparatus operated under these conditions. These are conductors and, consequently, lower the insulation resistance over the surfaces, making the current likely to creep from exposed live metal parts to the core, and so cause a burn-out.

Ordinarily, the deposit appears not to attack the insulation, and the only thing necessary to prevent trouble is to clean the machine at frequent intervals, testing its condition by readings of insulation resistance. In order that the surfaces may be readily cleaned, they should first have a good smooth finish, such as is obtained from several coats of varnish. Most machines have this finish when sent from the works, but under certain conditions it may become rough, and then it is necessary that the windings be revarnished.

The insulation resistance is most readily measured with a megger, or if this is not available, a high-resistance voltmeter may be used in the following manner:

First, read the voltage across the line; then connect the voltmeter in series with the insulation resistance (between a commutator bar and the shaft) and read the volts again.

If R is the resistance of the voltmeter, V the reading of the voltmeter across the line, and V_1 the reading in series with the insulation, then the resistance of the insulation is

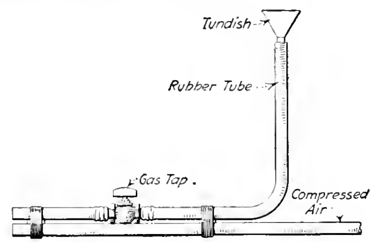
$$R_1 = \frac{R(V - V_1)}{V_1}$$

The resistance of the voltmeter is usually marked on the back of the instrument or on the carrying case; if not, it may be obtained from the makers.

When the insulation resistance of a machine shows a value of less than 250,000 ohms, this indicates that the windings are covered with dirt, and steps should be taken at once to clean them thoroughly. The best method is to thoroughly blow out the machine with compressed air. After this measure the insulation resistance. If it has reached a high value, say not less than 2 megohms, it indicates that the insulation surfaces are in good condition, but if little improvement is noted, thoroughly wipe all parts of the machine with a soft cloth and take insulation readings at frequent intervals during this operation, with a view to determining where the greatest improvement is effected. When the resistance reaches a good value, say not less than 2 megohms, the windings should be thoroughly sprayed with a good air-drying varnish. It is useless to spray the machine while covered with dirt, with the insulation resistance low; in fact, if this is done, it will be impossible to remove the dirt after it is coated with varnish, and the machine may have to be completely reinsulated.

Where compressed air is available, the best method for applying the varnish is as follows: Procure a length of ½-in. rubber tubing, say about 3 yd., and near one end fit an ordinary gas tap, as shown in the sketch, leaving about 3 in. of pipe from the tap. In the other end fit a tundish, then tie the paint tube on top of the air pipe. Varnish is poured into the tundish and will flow down the pipe, the supply being regulated by the gas tap. As it tries to pass the end of the air pipe it will be blown into a fine spray, which can be directed to the desired spot. The machine should stand for at least twelve hours after varnishing to allow for thorough drying.

In general it is desirable to give the machine more than one coat of varnish, and where the surface of the insulation is very rough it may be advisable to apply as many as four coats. These may be applied one after the other, allowing sufficient time between applications for the machine to dry, or they may be applied at convenient intervals. In the latter case, the machine must, of course, be thoroughly cleaned before each application. The point to keep in mind is that if the machine is to be easily cleaned there must be a good smooth finish on all surfaces over which the current is likely to creep, and this surface must be cleaned at frequent intervals.



Device for Applying Varnish

In dealing with direct-current apparatus, especial attention must be given to deposit forming on the under side of the armature coils between the commutator necks and the core, and on the mica between the commutator necks and the V-ring. Consequently, in cleaning such machines, these parts and the insides of the machines behind the commutator should receive particular care. A soft tape should be threaded under the armature coils, one at a time, and worked back and forth until all deposit is removed, especially from the corners where each coil leaves its slot.

Alternating-current apparatus is in general not likely to show a decrease in insulation resistance after running, as in alternating-current machines there are seldom any exposed live surfaces except collector rings, brush gear, etc., but the machines generally, and these parts especially, should be carefully cleaned at frequent intervals.

A New Canadian Periodical—"Mine, Quarry and Derrick" is the name of a new fortnightly magazine "devoted to the development of the mineral resources of Western Canada." The first issue made its appearance under date of Feb. 3, 1915, and it is promised by the publishers, Laurence & William, of Calgary, Alberta, to reappear "every second Wednesday." The staff consists of J. C. Murray, editor; W. C McGinnis, associate editor; R. W. Coulthard, contributing editor, and L. S. Kempher, manager. In the salutatory the intentions are declared to be to give real expression to the needs of the great Canadian West; to discuss the technical and other problems to be met; to correct errors and misconceptions, and, above all, to give the investing public the truth as to present conditions, all as relating to the fields of oil production, metal mining, coal mining, quarrying and the manufacture of cement and clay products.

Plate Valves for High-Speed Air Compressors

By G. J. MacFadden

SYNOPSIS—Points out the advantages of the plate valve and explains the construction and operation of several of the most widely used makes.

By the use of plate valves, a much higher piston or rotative speed is possible. Heretofore, the speed of air compressors has been limited by the air valves, as abnormal wear and breakage of valves resulted when the piston speed exceeded 500 ft. per min., caused by the excessive weight and high lift. The mechanically operated Corliss inlet valves have the disadvantage of semirotating surfaces which require positive lubrication and are liable to stick and cut. A complicated valve-gear is also employed, which requires adjustment at frequent intervals.

One of the principal advantages of plate valves is increased efficiency, due to the light weight of the valve proper and light initial tension of the valve springs, allowing the air in and out of the cylinder with small power consumption by the valves. With a light valve and low spring tension the minimum pressure is required to keep the valve open throughout that portion of the stroke in which it is operating. Another advantage is the low lift which, combined with lightness, reduces the momentum attained on opening, insuring quiet operation and little necessity of cushioning mechanism. The air is admitted to the cylinder in a constant stream and at lower temperature and higher pressure than where the ordinary chattering high-lift poppet valves are used. The valves are silent in operation up to the hignest speed, which demonstrates the absence of hammering and fluttering, and reduces wear of the valve and the valve seat. The cost of repairs with the standard makes of plate valves is small.

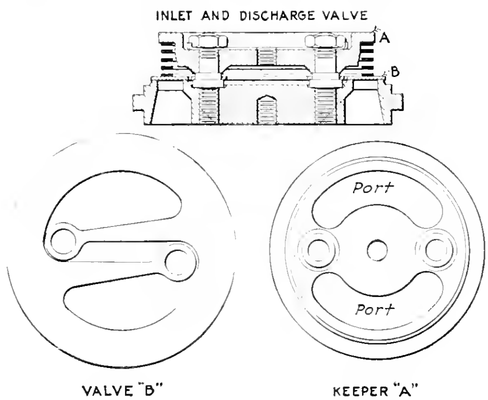


Fig. 1. The Borsig (German) Valve

The higher safe speed of compressors using plate valves means a reduced cost of installation, not only of the compressor unit, but of the building and foundation, since a compressor for a stated capacity, equipped with plate valves and operating at high speed, requires approximately two-thirds the floor space taken up by a slow-speed compressor equipped with the old-style poppet valves. In the case of motor-driven units high speeds mean the additional advantage of smaller and less expensive motors.

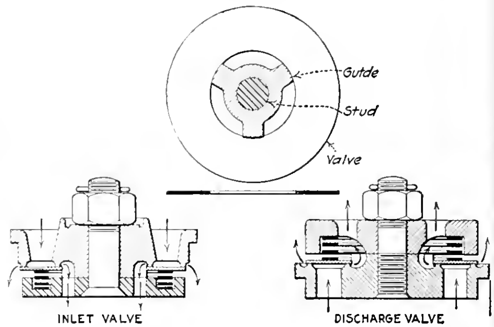


Fig. 2. Another German Valve

To sum up, the principal advantages of the use of plate valves are as follows:

1. Improved mechanical and volumetric efficiency over the old-style poppet valve.
2. Minimum wear; cost of repairs reduced to a negligible amount.
3. The valve requires no lubrication.
4. Silent operation at the highest piston speeds.

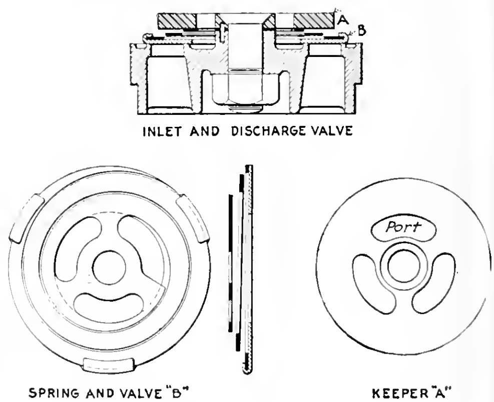


Fig. 3. Mesta Machine Co.'s Plate Valve

5. The air end is simplified, owing to the elimination of all complicated valve-operating mechanism.
6. Dependable and efficient at high speeds.
7. Floor space and cost of installation reduced on account of greater capacity of smaller units due to high speed.
8. Continuous operation under severe conditions.

Prominent American builders of large and medium-sized compressors have adopted the plate valve for use in their compressors only within the last two or three years. Conditions were ripe for the innovation, because of keen competition by foreign manufacturers, who have employed the plate valve with success for some years.

In the following description of plate valves only those of standard Continental and American construction will be discussed. They may, however, be taken as representative for the whole development along this line, since with few exceptions, they follow closely the original German design.

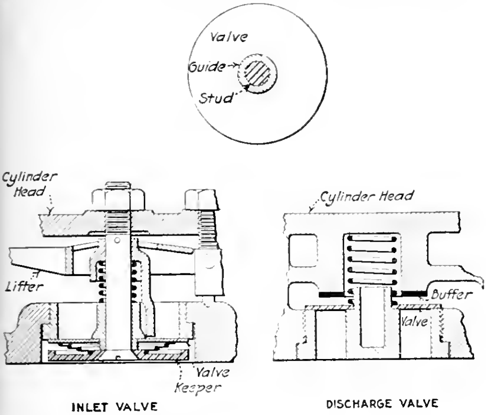


FIG. 4. VALVE USED BY THE CURTIS MANUFACTURING CO.

Fig. 1 shows a section elevation and plan view of the Borsig valve, manufactured by A. Borsig, Berlin. The valve consists essentially of a thin sheet-metal disk of light weight, and is made to form two spiral arms

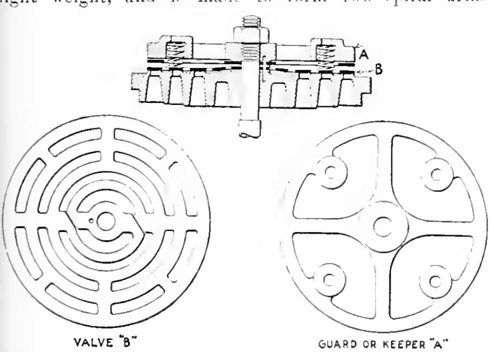


FIG. 5. THE ROGLER PLATE VALVE (INGERSOLL-RAND CO.)

secured at the center of the valve by two studs, one in each arm; a small movement of the valve arms is allowed on each stud, depending on the lift of the valve. Above the valve disk a keeper or stop is provided, in which a large helical spring is seated. This spring serves to load the valve and press it firmly on its seat. The point of support of the arms is located in the center of the valve lift so that the disk is bent upward when the valve is opened, and owing to the small mass of the valve proper, its inertia is negligible. The construction of this valve is such that it may be used for either discharge or inlet.

Fig. 2 shows a plate valve used by the *Zwichauer Maschinenfabrik Aktiengesellshaft Zwichau*, Saxony, one of the large compressor builders of Germany. The valve complete consists essentially of six pieces. The seat is a circular iron casting having either one or two ports. The keeper is a simple iron casting having ports cored through to allow the passage of air from the inner edge of the valve. The valve spring is of the helical type of rectangular section, allowing a much more compact arrangement where fully compressed than a spring of circular section. The valve keeper is provided with a recess of sufficient depth to accommodate the spring when the valve attains its greatest lift. The valve proper consists of a thin disk stamped from sheet steel, being centrally guided by projections on the valve seat. The valves are not interchangeable for inlet or discharge.

Fig. 3 shows the construction of the Mesta automatic plate valve, manufactured by the Mesta Machine Co., of Pittsburgh, Penn., under the Iversen patent. The valve

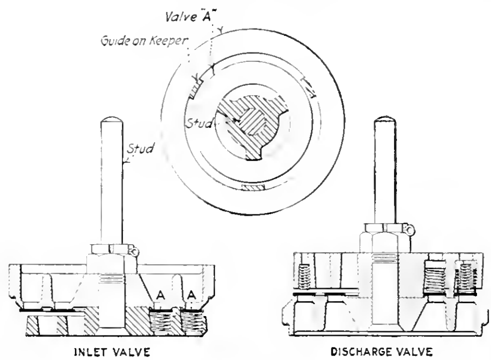


FIG. 6. THE "SIMPLATE" VALVE (CHICAGO PNEUMATIC TOOL CO.)

proper consists of a light, thin, annular steel plate, guided by a flat volute spring. The spring is permanently fastened to the valve plate by prongs or clips bent over the outside edge of the spring. The valve lifts parallel to the seat and employs no guiding surfaces or guide pins. The valve seat is a circular iron casting having one or more annular ports. The valve keeper consists of a thin plate of steel, with punched ports or recesses provided to allow the free passage of air from the inside of the valve.

Fig. 4 shows the details of the inlet and discharge valves made by the Curtis Manufacturing Co., of St. Louis, Mo. The valve proper is a thin disk stamped from sheet steel. The valve seat is of phosphor-bronze, having independent ports or cored passages for the flow of air. The inlet and discharge valves are of independent design, but are not interchangeable. The inlet-valve keeper is of steel and provided with a suitable recess to accommodate the valve spring. The valve complete is held in a pocket in the cylinder head by a flat-head stud. The discharge valve proper is screwed into a tapped hole in the air-cylinder head. The spring is held in a pocket and a seat is provided in the cylinder head to act as the valve keeper or buffer. These valves, due to their thin construction, permit the passage of air around the outside edge only, as the valve is guided on a circular projection at the center of the valve seat.

Fig. 5 shows a section of the Rogler plate valve, built by the Ingersoll-Rand Co., and which is essentially of German design. The valve proper is made of special steel, treated, tempered and ground. Narrow, integral spring arms, ground to about half the thickness of the valve proper to give them elasticity, are located at the middle portion of the valve. These arms act as a connecting means between the fixed and moving parts of the valve, holding the latter in one position and seating it always in the same place on the valve seat. The valve seat is of special material, cast with circular ports. The keeper is a special casting provided with four spring pockets to accommodate the four main valve springs which hold the valve on its seat against the slight tension of the integral valve arms. A cushion plate, fixed at the center only and having a certain amount of elasticity, is employed to cushion the valve at the point of full opening. It will be noted by referring to the cross-section that a washer is placed between the valve proper and the valve seat and between the cushion plate and the valve proper. All parts are kept from turning by a dowel pin and are clamped together by a through bolt.

Fig. 6 shows the "Simplate" valve, designed and built by the Chicago Pneumatic Tool Co. The seat is of special material cast with one or more circular ports, depending upon the size of the valve. The valve proper in the one-ported valve consists of a thin plate, or ring, stamped from sheet steel, heat treated and tempered, then ground to present a true surface on the seat. The multi-ported valves of larger size have two or three distinct and separate valve disks, operating independently of each other. These disks are similar to the one used in the one-ported valve, as described above. The valve keeper on the inlet valve is of special cast steel with suitable ports arranged to allow the flow of air from the inner valve disks. The discharge-valve keeper is of cast iron, provided with ports similar to the inlet-valve keeper. Both inlet- and discharge-valve keepers have drilled recesses for the accommodation of the valve springs. Plain, small, helical springs of light tension are employed on the inlet valve, while on the discharge valve, springs of slightly greater tension, together with buffer or cushion springs, are used. All springs are galvanized to resist the corroding action of the moisture in the air. Valve seat and keeper are held together, in the case of both inlet and discharge valves, by a centrally located stud and castle nut, as shown.

Steam Costs in 6600-Hp. Boiler Plant

By Frank G. Philo

SYNOPSIS—Interesting cost data of a boiler plant for a large manufacturing establishment.

The value of steam-cost data depends primarily on the accuracy with which the coal and steam are measured and the care with which the labor and all operating records are kept. This being the case, it will probably not be amiss to go into detail as to the methods used in obtaining the following data.

Coal Weighing and Analysis

The fuel burned is a mixture of No. 3 buckwheat with about 10 per cent. soft coal. To obtain the total weight of coal consumed as well as the proportions of the two coals mixed, the following method is used. The hard coal is weighed as received in the railroad cars, on carefully tested track scales which check within 10 lb. with standard weights. The hard coal is then dumped into a machine which mixes it thoroughly with the crushed soft coal. The mixture is carried overhead by a conveyor and dumped into cable cars of 2-ton capacity each. The weight of the mixed coal is obtained by weighing the small cars on a second set of scales at this point. From the hard-coal weights and the weight of the mixture the total weight used, as well as the percentage of each kind of coal in the mixture, is obtained. The automatic mixer is so designed that it can be adjusted to give any proportions of the two coals desired. The cost of the mixture is increased about one cent for each 1 per cent. of soft coal added. The function of the soft coal is to act as a binder for the small anthracite and to supply the necessary volatile matter which assists materially in starting a fire after cleaning periods. The soft coal also helps to burn out the fires more thoroughly before dumping.

Analyses of coal and cinders are made daily. The number of cars of coal which the sample represents, together with the road and car numbers, are entered on the laboratory sheet. The average analysis for the month is found by multiplying each analysis by the number of cars it represents and dividing the sum of these totals by the total number of cars used during the month.

The average analyses of the coal fired during the first six months of 1914 were as follows:

	Jan.	Feb.	Mar.	Apr.	May	June
Moisture	9 27	9 05	8 72	8 44	8.01	7.91
Ash (dry basis)	24 15	23 84	24 09	20 28	19.72	24.22
B.t.u (dry basis)	11,070	11,140	11,150	11,563	11,674	11,051
B.t.u (as fired)	10,043	10,132	10,178	10,587	10,739	10,177
Combustible (as fired)	68 82	69 27	69 29	72 99	73.85	69.79

Feed-Water Measurement

Feed water is measured by two venturi meters of 3000 and 4600 cu.ft. per hour capacity, respectively. The adjustments of these meters are checked weekly and once a month weight checks are run by passing water at working temperature and pressure through the meters into carefully weighed tank cars, which are run alongside the boiler house. These tank cars have a capacity of about 60,000 lb. of water. All tests are run for at least 30 min., so the personal errors in starting and stopping are small. The errors of the meters were found to be practically constant for any given rate of flow. The average error over the working range covered in practice was found and a correction applied to the daily meter readings. The average error of the meters was found to be about ¾ per cent. low.

All water blown from boilers and economizers, as well as all water discharged in emptying boilers and economizers for repairs, is subtracted from the water registered by the meters. This water amounts to from 1 to 2 per cent. of the total water passed through the meters during the month. The blow-down pipes from each boiler are provided with plug cocks and valves. The blow-down headers from each battery of boilers have gate valves. All blow-down valves and lines are inspected daily to insure against loss of water from boilers by leakage.

Records of Operation

Daily reports are made showing the weight of water evaporated, the average rating developed by the boilers, feed-water temperatures, steam pressure, economizer inlet and outlet water and flue-gas temperatures, flue-gas analyses, coal and cinder analyses and all useful information regarding the operation of the boiler house.

All materials and supplies are kept in a main storeroom and can be obtained only upon presentation of a signed requisition from the foreman in charge. All labor and materials used by other departments for repairs and maintenance of the boiler house are charged against the boiler house at the end of each month. Thus the cost of labor and material furnished by the pipe, electric, machine and carpenter shops for work done in the boiler house is always obtainable. In reporting materials used all supplies amounting to $20 or over are itemized. Time slips for all employees of the boiler house are filled out by the foremen and are sent to the time keeper's office every day.

Load Factor

The load factor of this plant is very high as the plant is run at full load 24 hr. per day, and about 26 days per month. During the shutdown periods about one-quarter of the total rated boiler capacity is in service.

LOAD ON BOILERS

	Jan.	Feb.	Mar.	Apr.	May	June
Average b.hp. per hr. (operating hr.)	7698	8070	7094	6341	6260	6151
Average b.hp. per hr. (total hr.)	7501	7781	6357	5764	5878	5626
Average load factor (operating hr.)	116 6	122 3	107 5	96 1	94.9	93.2
Average load factor (total hr.)	113.7	117.9	96.3	87.3	89.1	85 2

Total rated b.hp. of plant, 6600.

Average operating boiler horsepower = average boiler horsepower developed per hour while the plant is in operation.

Total average boiler horsepower = average boiler horsepower developed during total hours during the month.

Operating load factor = load factor based on operating boiler horsepower =

$$\frac{\textit{Operating boiler horsepower} \times 100}{6600^*}$$

Total load factor = load factor based on total average boiler horsepower =

$$\frac{\textit{Total average boiler horsepower} \times 100}{6600}$$

OPERATING COST OF EVAPORATING 1000 LB. WATER FROM AND AT 212 DEG. F., CENTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	10.64	10.38	10 76	9.62	9.82	9.67
Labor	2.60	2.56	2.81	2.89	2.99	3 12
Total	13.24	12.94	13.57	12.51	12.81	12.79
Operating cost per boiler hp.-hr., cents	0.46	0.45	0.47	0.43	0.44	0.44

*Rated capacity of plant.

OPERATING COSTS AS PER CENT. OF TOTAL OPERATING COSTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	80 4	80 2	79 3	77 0	76.7	77 2
Labor	19 6	19.8	20.7	23 0	23.3	22 8

	Jan.	Feb.	Mar.	Apr.	May	June
Tons coal used	12,331	11,145	10,450	8,392	8,865	8,136
Cost per 2000 lb. delivered	$1.66	$1.68	$1 68	$1.64	$1 67	$1 66
Lb coal per boiler hp.-hr.	4.419	4.263	4.419	4 044	4.054	4.017
B.t.u. per lb. (as received)	10,043	10,132	10,178	10,587	10,739	10,177
Efficiency (boiler, economizer and furnace)	75 5	77.6	74.4	78.3	76.9	81 1
Efficiency (boiler and furnace)	69 4	71 2	69 0	72.6	71.4	74 2

Efficiency figures are based on the total coal used during the month, including that used for starting and banking fires, etc. The total water evaporated is checked against the total coal fired. The gain in efficiency due to the economizers is figured from the rise in the feed-water temperature through the economizers.

OPERATING LABOR COSTS PER TON OF COAL FIRED, CENTS

	Jan.	Feb.	Mar.	Apr.	May	June
Handling coal	4.40	4.67	4.90	4 39	4.44	4.78
Firing coal	21.25	21.84	21.19	24 08	24.70	26.01
Removing ashes	3.26	3.28	3 38	4 02	4.24	4.46
General	11.63	11.64	14 44	16 59	17.42	18.26
Total	40 51	41 43	43 91	49 08	50 80	53 51

INDIVIDUAL COSTS AS PER CENT. OF TOTAL COSTS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	75 9	75 0	75 2	71 4	69 6	70 1
Operating labor	18 5	18 5	19 7	21 3	21.2	22 6
Maintenance labor	1 1	0 7	0 9	1 6	1 1	1 2
Maintenance material	4 5	5.8	4 2	5 7	8 1	6.1

TOTAL COSTS OF COAL, MATERIAL AND LABOR, DOLLARS

	Jan.	Feb.	Mar.	Apr.	May	June
Coal and freight	20,469.46	18,723.60	17,556.00	13,762.88	14,804.55	13,505.76
Operating labor	4,998.98	4,617.37	4,588.59	4,118.79	4,503.42	4,353.57
Maintenance labor	298.63	171.59	213.89	307.28	238.90	238.40
Material	1,204.68	1,437.33	972.49	1,100.50	1,725.73	1,179.32
	26,971.75	24,949.89	23,330.97	19,289.45	21,272.60	19,277.05

DIVISION OF LABOR, BOILER ROOM

	6 a.m.-6 p.m., Day Shift	6 p.m.-6 a.m., Night Shift
Foremen	1—12 hr., $3.25	1—12 hr., $3.25
Water tenders	1—12 hr., $2.75	1—12 hr., $2.75
Ash men	3—12 hr., $2.16	3—12 hr., $2.16
Repair men	11—10 hr., $2.16	1—12 hr., $2.16
Firemen	16—12 hr., $2.75	16—12 hr., $2.75
Coal handlers	7—12 hr., $2.16	
Chief engineer	1— 8 hr., salary	
Efficiency engineer	1— 8 hr., salary	
	41 men	22 men

Total 63 men

The boiler equipment consists of fourteen 300-hp. B. & W. boilers and six 400-hp. Edgar water-tube boilers. All boilers are equipped with Green economizers. One foot of economizer surface is provided for each two feet of boiler-heating surface served. All boilers are hand-fired and are equipped with Grieve grates and forced draft produced by a 125-hp. Green fan. The grates have about 8 per cent. air space. The ratio of grate surface to heating surface is 1 to 30. The ash hoppers are of cast iron lined with brick. Ashes are dumped into small cars of one-ton capacity each and are pulled up an incline by a steel cable and dumped into the railroad cars. Coal is handled and delivered to the bunkers by the Mead-Morrison system of cable cars.

Foreign-Built Vessels Admitted to American Registry—Under the act of Congress of Aug. 18, 1914, the foreign-built vessels admitted to American registry up to Feb. 19, 1915, have numbered 129, with 468,509 gross tons, or 303,284 net tons.

The Horsepower Constant is the number of horsepower per pound of mean effective pressure developed by an engine when running at its normal speed. It will be different for different speeds. Knowing the constant, one need only multiply the mean effective pressure (obtained from an indicator diagram) by this constant to know what indicated horsepower the engine is developing. Evidently, by the definition, the horsepower constant is all of the "PLAN" formula except the P.

Testing Small Centrifugal Pumps

By M. R. Blish

SYNOPSIS—Simple directions for making capacity tests of centrifugal pumps.

Although the methods and apparatus to be described are particularly adapted to testing small pumps, they apply with limitations to pumps of large capacity.

Apparatus

The apparatus for measuring the quantity of water delivered by the pump is most important. Where available, weighing tanks will prove most satisfactory for this purpose. Usually, they are arranged side by side, and in between the two a hopper is so placed that the water may be turned from one into the other without interrupting the flow.

Each weighing tank should be of such capacity that it will accommodate as much water as will flow in at least two minutes, and have a quick-acting delivery valve of such size that the water can be let out of the tank in one-half the time required to fill it. This will then give time for closing the valve for the reception of the next charge of water and for caring for any unseen delays that may occur while the other tank is being filled. A satisfactory valve for these tanks is a large gate valve in the floor of the tank, operated by a steam or air cylinder on the outside and held to its seat by the weight of the water. This form of valve may be easily opened or closed and the controlling valves placed within easy reach of the man operating the scales. The scale beams should be so arranged that they may be read from the same platform.

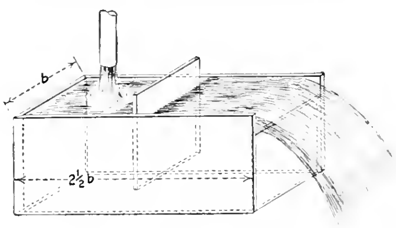


Fig. 1. Partition to Obtain Uniform Flow

Another form of apparatus used to measure the quantity of water is a single large tank fitted with a weir, as in Fig. 1. The capacity of the tank should equal about five minutes' discharge of the pump. It can be made of steel (or wood lined with sheet zinc) and the plan dimensions such that the length is two-and-a-half times the breadth. The weir is placed in the end, not along the side of the tank, and should extend the width of the tank to avoid end contractions* of the water passing over the weir. A partition running parallel with the weir and extending from the top to within 2 ft. of the bottom divides the tank into two compartments. The water should come into the tank on the side of the partition opposite the weir. This arrangement will prevent a serious "velocity of approach" of the water to the weir. If the tank is of wood, it will be necessary to provide a strip of ¼-in. or $\frac{3}{16}$-in. iron for the weir, which may be either set into the wood or screwed to the inside of the tank. The sharper the edge of the weir, the better the results that will be obtained.

*When water escapes to the atmosphere or from one vessel to another through a "drowned" (submerged) orifice, or whether it flows from an open channel or nozzle, the stream will get smaller—contract at a certain distance from the orifice; hence the term contraction.

Still another form of apparatus for measuring the delivery of the pump consists of a large tank of rectangular plan, from one end of which a wooden trough extends, as in Fig. 2. This trough is inclined at an angle not to exceed ten degrees from the horizontal, and is of such width and depth that it will carry away the overflow from the tank when inclined at the angle selected. The pitch of the trough must not be too great, for this would mean a high velocity through it, thus bringing about a large friction loss. However, it must be inclined sufficiently to carry away the pump delivery. If lined with zinc or copper sheeting, the sides of the trough will reduce the friction loss. Provision must be made for accurately measuring the depth of water in the channel or trough and a current meter for obtaining the velocity of the water in the channel is also necessary.

The water must start from the tank into the channel with almost no initial velocity; more accurate measurements are then possible. To provide for this condition a partition must be inserted across the short dimension of the tank, as described in the tank with the weir.

The most common type of drive for the small centrifugal pump is the electric motor. The connection to the pump is often by a belt long enough to allow 10 to 12 ft. from the motor-shaft center to the pump-shaft center.

The power input to the motor is measured by an ammeter and a voltmeter if using a direct-current motor, and by a wattmeter if using alternating current. In the direct-current system the voltmeter is shunted across the line at some convenient point near the motor and the ammeter is placed in series with the armature circuit. In the alternating-current system the wattmeter is placed in

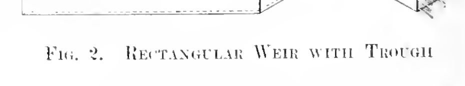


Fig. 2. Rectangular Weir with Trough

series with one of the windings. The reading must be multiplied by three if a three-phase circuit is used. In either system provision should be made to vary the speed of the motor.

If it is possible to substitute a direct-connected motor for the belt drive, better results will be obtained in that it will be possible to measure the power input to the pump more accurately. A convenient method is to insert between the motor and pump couplings a direct-reading dynamometer which records the horsepower upon a graduated scale. However, this is a rather expensive apparatus and is necessary only when great accuracy is required.

A strainer and check valve should always be placed on the lower end of the suction pipe, Fig. 3. The strainer will prevent any large pieces of foreign matter being drawn into the pump. The valve will prevent the suction

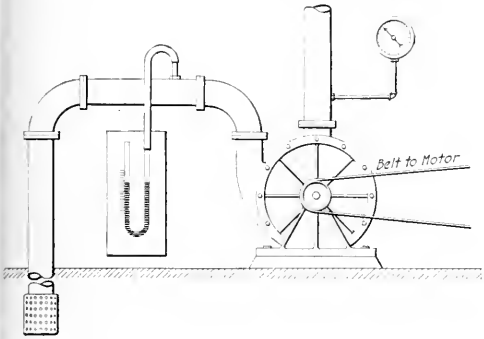


FIG. 3. U-TUBE FOR MEASURING SUCTION HEAD

head being lost, if the pump is shut down for a short time, and will also assist in starting the pump.

To measure the suction head a mercury column, consisting of a glass U-tube a little more than half full of mercury, is attached to the suction pipe as nearly as possible to the pump. A vacuum gage could be used for this purpose and attached to the same place on the suction pipe. A thermometer is needed in the well to determine the water temperature.

To measure the delivery head a pressure gage is attached to the delivery pipe near the pump. A throttle valve placed in the delivery pipe near its discharge end enables one to vary the pressure against which the pump

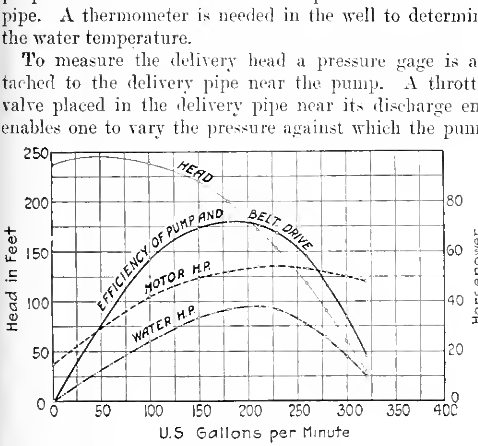


FIG. 4. HORSEPOWER-QUANTITY CURVES

works. Two speed counters are usually provided, one for taking the motor and the other for taking the pump revolutions.

An opening in the pump casing is necessary to provide for starting. This hole is fitted with a plug and should be from 1 to 1½ in. in diameter.

Having provided suitable apparatus, there are two tests that may be run—the constant speed and the variable speed.

CONSTANT-SPEED TEST

This is the most valuable test because a centrifugal pump is designed to run at a constant speed. Having filled the pump with water through the hole in the casing, open the throttle valve in the delivery pipe and start the motor. When the pump is running at its normal speed see that the throttle valve is wide open so that only the static head to the point of delivery and the friction head in the pipe exist. This will be the condition of largest capacity, smallest head.

The following readings are taken and repeated every two or three minutes for the same conditions until five are recorded, and for each new set of conditions: Voltage, amperage (if direct current is used), wattage (if alternating current is used), suction pressure, delivery pressure, speed of motor, speed of pump, and the necessary readings for determining the quantity pumped. One reading of the thermometer will usually be sufficient during the test, as the water temperature will vary slightly, if any.

The delivery throttle valve may now be closed to some extent to shut off the flow and correspondingly increase the pressure. Readings are taken at every 5-lb. increase

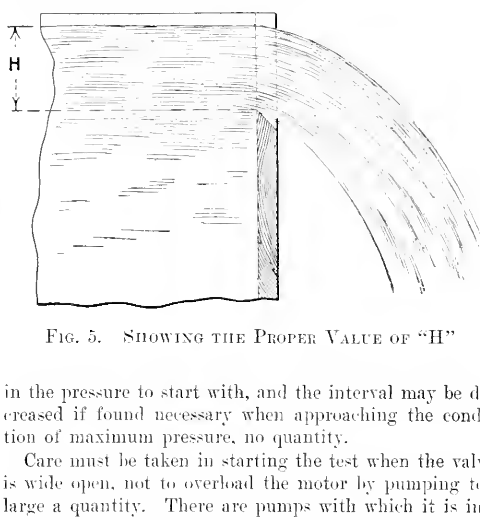


FIG. 5. SHOWING THE PROPER VALUE OF "H"

in the pressure to start with, and the interval may be decreased if found necessary when approaching the condition of maximum pressure, no quantity.

Care must be taken in starting the test when the valve is wide open, not to overload the motor by pumping too large a quantity. There are pumps with which it is impossible to overload the motor, as the motor horsepower—quantity curve—is of a form shown in Fig. 4. If a constant-speed motor is not being used, it will be necessary to slow down the motor as the quantity decreases, as the tendency will be to speed up the pump beyond its rating.

If the well from which the water is pumped is not of sufficient capacity, the level will fluctuate somewhat, provided the weighing-tank method is used. This will be noted only if the water pumped is let back into the well after being weighed.

Before finishing the test the height of the center of the pressure gage above the water level and also the height of the point of attachment of the mercury gage above this level should be recorded.

The following calculations will be necessary to convert the readings taken into terms for plotting the curves: Obtain from a table of the properties of water at different temperatures the weight of a cubic foot of water at the temperature recorded. With this figure the number of cubic feet pumped per second may be obtained from the pounds per second, if the weighing-tank method is used.

Number of Readings	Motor			Pump			Weighing Tank				Discharge Speed, Ft. per Sec.	Pressure Head, Ft.	Difference in Elevation of Gages, Ft.	Suction Head, Feet	Speed Head, Feet	Total Head, Feet	Efficiency of Motor	Horsepower of Motor
	Current Input	Voltage	R.p.M	Discharge Pressure	Suction Pressure in Hg	R.p.M.	Time, Seconds	Weight of Water, Lb.	Pounds per Second	Cubic Feet per Second								

Performance at N R.p.M.							Remarks:
Number of Readings	Total Head, Feet	Discharge		Horsepower of Motor	Water Horsepower	Water Hp.	
		Cubic Feet per Second	U. S. Gallons per Sec.			Motor Horsepower	

Fig. 6. Form for Recording Centrifugal-Pump Test Data

By the weir method of measurement the quantity may be calculated directly by the use of Francis' formula:

$$Q = 3.33\, b H^{\frac{3}{2}}$$

in which

Q = Cubic feet per second;
b = Width of weir in feet;
H = Height of water level above the weir.

Care should be taken that it is measured far enough back from the weir so that the true height is obtained, as in Fig. 5. An accurate method of obtaining height H is to measure the level of the water by means of a hook gage suspended over the center of the tank.

With the channel method of measurement the water cross-section must be determined in some manner, and this section in square feet multiplied by the velocity of the water in feet per second will give the flow or discharge in cubic feet per second.

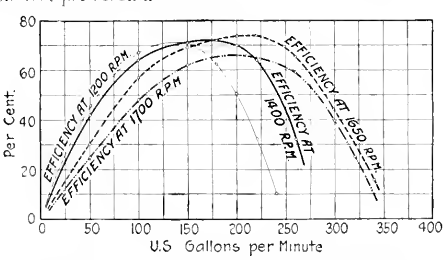


Fig. 7. Results of Speed Test on 12,000-Gal.-per-Hour Turbine Pump

The pressure head P in feet is obtained from the gage pressure in pounds per square inch by multiplying the same by the factor 2.31. The suction head in feet is obtained from the suction pressure in inches of mercury by multiplication by the ratio 17 : 15.

The total head against which the pumps are working is obtained by addition of the suction head, pressure head and the vertical distance in feet between the center of the pressure gage and the point of attachment of the mercury gage. The friction head in the delivery pipe, the suction pipe, the foot valve and strainer are accounted for by readings of the pressure and suction gages.

The horsepower output of the motor, in the case of direct current, is obtained from the product of the amperage, voltage and motor efficiency, divided by the factor 746. The motor efficiency must either have been determined beforehand by separate test or obtained from the motor manufacturers. In the case of alternating current the motor output is the watts input times the motor efficiency.

The belt loss is subtracted from the motor output to find the true power input to the pump. This loss will depend upon the condition of the belt texture, the tension put upon the belt and the amount of slip. The variation of the ratio of the motor and the pump speeds gives some indication of the loss of power in the belt.

The water-horsepower exerted by the pump is obtained as follows:

$$\textit{Water-horsepower} = \frac{62.5 \times QH}{550} = \frac{QH}{8.8}$$

where

Q = Cubic feet water per second;
H = Total head on the pump in feet.

The efficiency of the pump is then the water-horsepower divided by the horsepower input to the pump.

Fig. 6 is a form showing the readings necessary and the factors to be calculated. Fig. 7 shows the curves obtained from an actual constant-speed test on a small turbine pump of 12,000 gal. per hr. capacity. Without doubt, it will be impossible to keep the pump at exactly a constant speed, and to plot the curves for constant speed it will be necessary to correct the readings of quantity, head and horsepower by means of the following formula:

$$Q' = Q \times \frac{N'}{N}$$

$$H' = H \times \left(\frac{N'}{N}\right)^2$$

$$HP' = HP \times \left(\frac{N'}{N}\right)^3$$

where Q', H' and HP' are the quantity, head and horsepower at speed N', which is the constant speed at which the pump should run, and Q, H and HP are at the speed N, the actual speed recorded while the readings are being taken.

Variable-Speed Test

Such a test may be run when it is the desire to know at what speed the pump will give the best efficiency; in other words, for what speed the pump was designed.

The apparatus used in the former test can be used in this test. Commence at a speed somewhat below that which has been judged to be the normal speed of the pump, and with the valve wide open take readings of the power input to the motor, speed of motor, speed of pump, pressure gage, suction gage and quantity pumped. Take only one set of readings, and then increase the delivery pressure and take another set. Continue to increase the pressure, taking readings at every change until the throttle valve is entirely closed. Then open the valve, speed up the pump 50 or 100 revolutions and take the same readings as before with the same increases in pressure.

The calculations may be made by the same formula and rules as formerly, but in plotting the curves it will be necessary to plot only the efficiency curves to ascertain at what speed the pump should be run to work most economically. A set of such efficiency curves taken from a test is shown in Fig. 7. The normal speed of the pump was 1650 r.p.m., at which speed, as shown, the best efficiency was obtained.

One Thing to Remember is that if a man does not know, he cannot be cussed into knowing, especially if you have only a short time in which to give him the treatment. A better plan is to wait an opportunity, and not let it pass when it comes, to talk with the man and do your best to give him help by way of instruction and advice.—D. R. MacBain, before the Traveling Engineers' Association.

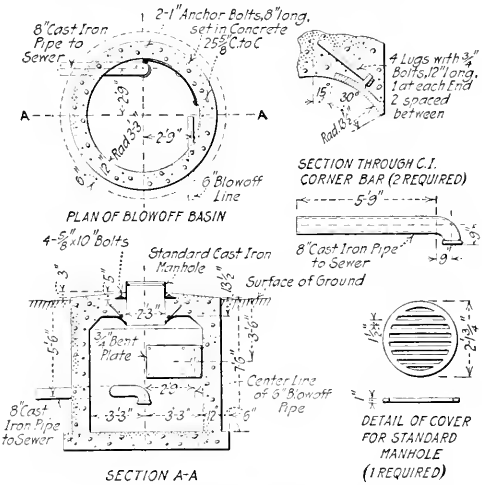
Three-Metal Bronzes—A description of the ternary metals: Copper and tin with lead, zinc, phosphorus, manganese and aluminum. Lead imparts plasticity to bronze, and diminishes hardness and temperature changes ("imparts a lower mutual freezing point"). Microscopic examination shows that the lead is distributed throughout the mass. Segregation, to which bronzes rich in lead are liable, is prevented by the addition of 1 per cent. nickel, sulphur added as galena, phosphorus, or arsenic. A small addition of zinc does not materially alter the structure of bronzes, while ductility and tensile strength are slightly increased. Bronzes containing zinc are more easily forged and cold-rolled and are less readily corroded by sea water. Phosphorus may exist entirely as solid solution (up to 1 per cent.) or as Cu_3P; it greatly increases the hardness and resistance to wear, while impairing the tensile strength, elasticity and elongation. The maximum in commercial bronzes is about 0.8 per cent. P, with about 8 per cent. Sn. The valuable properties of manganese bronze are its strength and noncorrodibility; commercial products often contain more aluminum than manganese. True aluminum bronze seldom contains more than 11 per cent. Al; it is useful in casting, though it shrinks considerably. The addition of tin increases its ductility.—"Journal of the Franklin Institute."

Concrete Blowoff Basin

By A. D. Williams

A blowoff basin or tank is one of those details of a power plant that often cause trouble. Restrictions are frequently imposed regarding the discharge of steam into sewers, and much steam is released where the blowoff pressure becomes equal to that of the atmosphere. The basin, Fig. 1, was designed for the East Fifty-third St. station of the Cleveland municipal electric-light plant and presents desirable features. It is constructed of plain 1 : 2 : 4 concrete, as it is buried in the ground. For use above ground the design must be modified and strongly reinforced concrete or steel plate used, the latter preferably.

This basin is designed to separate the steam from the hot water by whirlpool action, the blowoff pipe entering the basin tangentially, as shown in the plan section. The



Section and Details of Concrete Blowoff Tank

concrete is protected from the action of the entering stream by a ¾-in. bent plate. In action the water has a tendency to spread out on the walls of the basin, leaving the center open for the escape of the steam released. This action of the water explains the location of the cast-iron waste pipe close to the wall, where it will commence to take water to the sewer as soon as the whirling water covers it. The lip around the manhole and the curved top are designed to prevent the whirling sheet of water from spreading on the top and trying to climb out of the manhole. The curve and lip work upon the same principle as similar parts of a steam separator, and throw the water down into the tank.

To simplify the form work required in constructing the tank, the top may be chamfered as indicated by the dotted lines, at one side of section AA. In building a basin on this design the internal form is best constructed of sheet steel, galvanized or plain, held in place by a wooden skeleton built so that a man can work inside the form to place the concrete bottom of the tank. In this way any seam between the walls and the bottom can be avoided.

The basin is designed to receive the blowoff from six boilers with 10,134 sq.ft. of heating surface each. If desired, the inside diameter of the basin may be increased, but it would be inadvisable to reduce the diameter, as the blowoff water enters it at a high velocity.

Razing a Brick Chimney

An extremely hazardous method used by a wrecking company to raze a brick chimney is shown in the illustration. This chimney was 6x6 ft. inside and 125 ft. high, and belonged to an abandoned power plant. Fig. 1 shows the method used. The bricks were dug out one on side and three jack-screws placed in the opening; then those on the opposite side and also back to the center of the chimney were knocked out. The idea was to tip the stack over with the jack-screws, but too much of the brickwork had been dug out and the remaining bricks failed. The result was successive failures which let the stack down almost vertically, as shown in Fig. 2. The fountain-like upheaval of bricks in Fig. 3 would make it appear that the base was blown out from under the stack, but such was not the case.

Fig. 1. Method Employed

Fig. 2. Beginning to Collapse

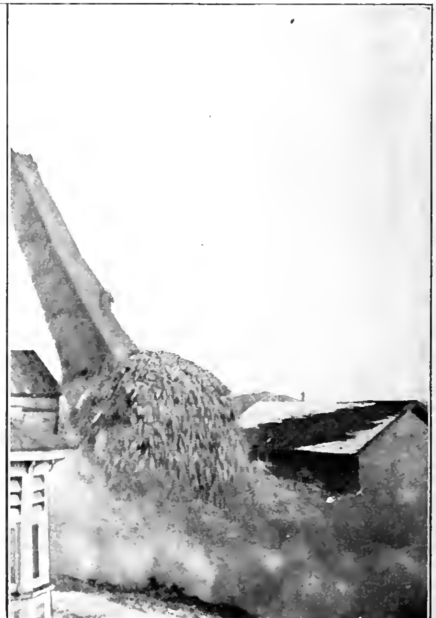


Fig. 3. Resembling an Explosion

Fortunately, no one was hurt by the premature falling of the chimney. There were two men on the scaffold when it started to collapse, but they jumped down and escaped from the danger zone. The top of the stack fell only forty feet from the base. This method is not to be favored, even when it is desired that the chimney fall within a small radius.

The whole circumstance furnishes a good illustration of the rule-of-thumb method used by many contractors, instead of making a few simple calculations. It is likely that this same process had been successfully used before on a small stack, therefore they supposed it would do for all others, but a method which proved entirely satisfactory in handling a small stack might not be at all successful for a large, heavy one. Many serious accidents have occurred in trying to adapt methods suitable enough in one case, but entirely inadequate in another. It is to be hoped that they will not experiment again.

Ocean Volume to Land Area—One per cent. of the contents of the oceans would cover all the land areas of the globe to a depth of 290 ft.—U. S. Geological Survey.

Two Causes for a Belt Not Running True upon properly built pulleys mounted upon correctly aligned shafting: The belt may not have been made straight in the first place, or the ends may not have been joined squarely. Otherwise there may have been a lack of uniformity in the texture of the hides from which the belt was made; belly leather toward one edge and flank leather toward the other, and the two stretching unequally.

Stop Acts When Rod Breaks

The value of a dependable safety stop on a steam engine was demonstrated a few days ago, when the piston rod of a 23x36-in. Wright engine parted. The engine was operating in the basement of the J. T. Perkins Co.'s factory, Kent Ave. and Hooper St., Brooklyn, N. Y.

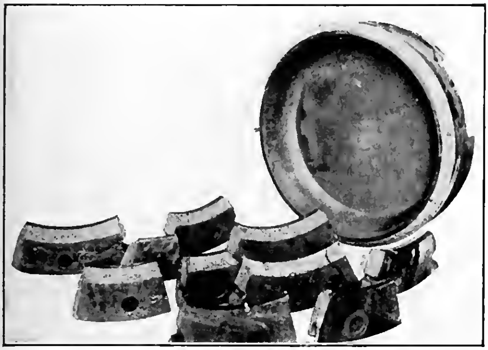


FIG. 1. CYLINDER HEAD AND PIECES OF THE FLANGE

The rod parted at the keyway in the crosshead, resulting in the knocking out of a cylinder head, breaking the flanged part into small pieces clean around the body of the head, as shown in Fig. 1.

No one was injured, and the property damage was slight. Fortunately, eight bales of camels' hair, weighing about 400 lb. each, were piled in line with the cylinder, and these received the head and piston as they were driven from the cylinder, and undoubtedly saved the lives of two operators who were working on a machine in line with the cylinder.

The engine was running at a speed of 90 r.p.m. with a boiler pressure of 125 lb. The piston rod shows on the face of the fracture that the break for the most part was old, the lighter surface at the right side of the right

FIG. 2. THE LIGHT SHADING INDICATES THE NEW FRACTURE OF THE PISTON ROD

view of Fig. 2 indicating the new fracture in the metal. The break was evidently caused by ordinary working strains, the metal appearing to be of good grade.

When the rod parted, the Wright safety stop, which is designed to operate with both high and low speeds, threw the catch blocks on the steam valves out of action, allowing the valves to remain closed and so preventing steam from entering the cylinder.

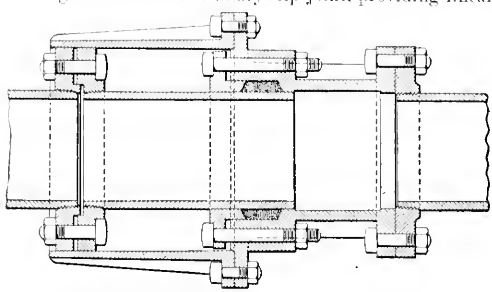
Because of the prompt action of the engine stop and the non-escape of live steam at boiler pressure into the factory, damage to the goods was prevented and the possibility of a panic and loss of life was avoided.

Ross Expansion Joint

The illustration herewith shows an expansion joint, the primary feature of which is that of guiding the pipe line so that it will be in alignment with that part of the piping which is held rigid, and thus prevent the ordinary wear and tear on packing experienced in slip-tube expansion joints. This joint automatically permits a lengthening or shortening of the pipe line to which it is applied up to a maximum of a 4-in. change of length without creating strains or distortions.

Referring to the illustration, the flanges, which are at each end of the joints, are of a size to permit of joining with the pipe-line flange on the larger end, the flange on the smaller end being bolted to a standard fitting which is anchored, or to the pipe line that is properly guided and anchored.

If it were not for the outer sleeve this device would be nothing more than an ordinary slip-joint, providing lineal



SECTION THROUGH ROSS EXPANSION JOINT

play for expansion and contraction. The slip-joint section, however, is of improved construction, as the packing space is ample and the slip tube is made of bronze, so that it will not rust in the packing.

The particular feature of this joint is the outside sleeve, which introduces an effective and rigid guide. This sleeve is cylindrical, machined on the inside and bolted to the body. The companion flanges, which travel in this guide, according to the amount of contraction or expansion of the pipe line, are machined on their peripheries to secure alignment, and wear of the packing of the slip joint and sagging of the line at the expansion joint are avoided. This prevents the tendency to leak and the joint will remain tight for long periods without adjustment of the packing.

This type of joint is made for a pressure of 200 lb. per sq.in., in all sizes up to and including 24 in. Each size will accommodate 4 in. of travel for expansion and contraction, and if a longer traverse is desired, special joints can be obtained.

This expansion joint is manufactured by the Alberger Heater Co., Chicago and Granger St., Buffalo, N. Y.

Idle Boilers should be thoroughly washed out and dried. Trays with unslaked lime should be placed inside and the boilers should be closed air tight. If the boiler is to stand ready for immediate use it should be filled with water to which burnt lime has been added, but unless the boiler is one of a battery and is kept warm, it is likely to condense atmospheric moisture from outside and corrode if filled with water.—Exchange.

Forty Years' Advance in Internal-Combustion Engines

Reference to the opposite page affords striking contrast between the internal-combustion engine of forty years ago and the present highly developed product in its special adaptations to various kinds of service. The two upper views represent the machines exhibited at the Centennial Exposition at Philadelphia in 1876, and among the rest are some that will be seen at the Panama-Pacific Exposition.

While the first attempts to produce an internal-combustion engine date back to the latter part of the eighteenth century, when gunpowder was used as the energy-producing medium, little was accomplished until 1860, when Lenoir placed on the market the first practical engine. This was horizontal, double-acting, and the cycle was patterned somewhat after the steam engine, the charge being drawn in during the first half of the stroke, ignited, and expanded during the latter half, then expelled on the return stroke. Owing to its extravagant use of gas, however, the Lenoir engine did not meet with much success.

The next engine to attract popular attention was the Otto and Langen, brought out in 1866. This was entirely different from the Lenoir and embodied the atmospheric free-piston principle. It consisted essentially of a long cylinder open at the top and containing a piston, the rod of which carried a rack. By means of a special clutch and pinion this rack was made to engage with the flywheel shaft on only part of the down stroke and that part of the up stroke during which the charge was being drawn into the cylinder. The operation was essentially as follows:

The mixture was drawn in for about one-sixth of the stroke and was then ignited by a naked flame, whereupon the rack disengaged from the pinion and the piston was projected upward: the latter part of the stroke, after the gases had expanded and cooled, being due to the inertia of the piston. On the downward stroke the rack engaged the pinion and the weight of the piston, aided by the atmospheric pressure on its upper side, performed useful work and stored energy into the flywheel. As the pressure of the gases below the piston increased above the atmosphere, they were slowly expelled from the cylinder and the speed of the piston decreased. At this point the pinion disengaged, only to engage again at the beginning of the up stroke for drawing in the next charge. The admission of the charge, ignition and exhaust were controlled by eccentrics and there were about 20 strokes per minute.

The engine was essentially limited in output and a great drawback was its irregular and extremely noisy operation. This led Otto to bring out, in 1876, a new engine operated on the four-stroke cycle (Beau de Rochas cycle) which was destined to revolutionize the gas-engine industry. It was the first gas engine to use compression and in principle formed the basis of the modern internal-combustion engine.

Just previous to this, however, in 1873, a Philadelphian by the name of Brayton brought out an oil engine in which the oil and air were mixed under considerable pressure outside the engine and passed into the cylinder through a fine-mesh wire screen, burning just beyond it, the object of the screen being to prevent backfiring into the port. The mixture was admitted for practically one-third the stroke and burned at a uniform pressure. The inlet valve then closed and the heated products of combustion forced the piston to the end of the stroke. The exhaust port opened just before the end of the stroke and on the return stroke compression was carried to the pressure in the air and fuel tanks.

Engines of this type were built in sizes of 1 to 10 hp., and were extensively used, the chief troubles being backfiring and the extinguishing of the pilot flame. Also, the addition of compressors for the oil and air made the installation somewhat cumbersome.

Without attempting to enumerate or describe the intermediate steps in the development of the gas and the oil engine, associated with the work of Dugald Clerk, Dr. Diesel and others, we will pass to a consideration of some of the present-day types. The familiarity of the reader with the principles of operation involved and their general construction makes a description unnecessary; hence, space will be devoted only to certain comparative features, some of which are included in the following tabulation:

COMPARATIVE FEATURES OF DIFFERENT TYPES

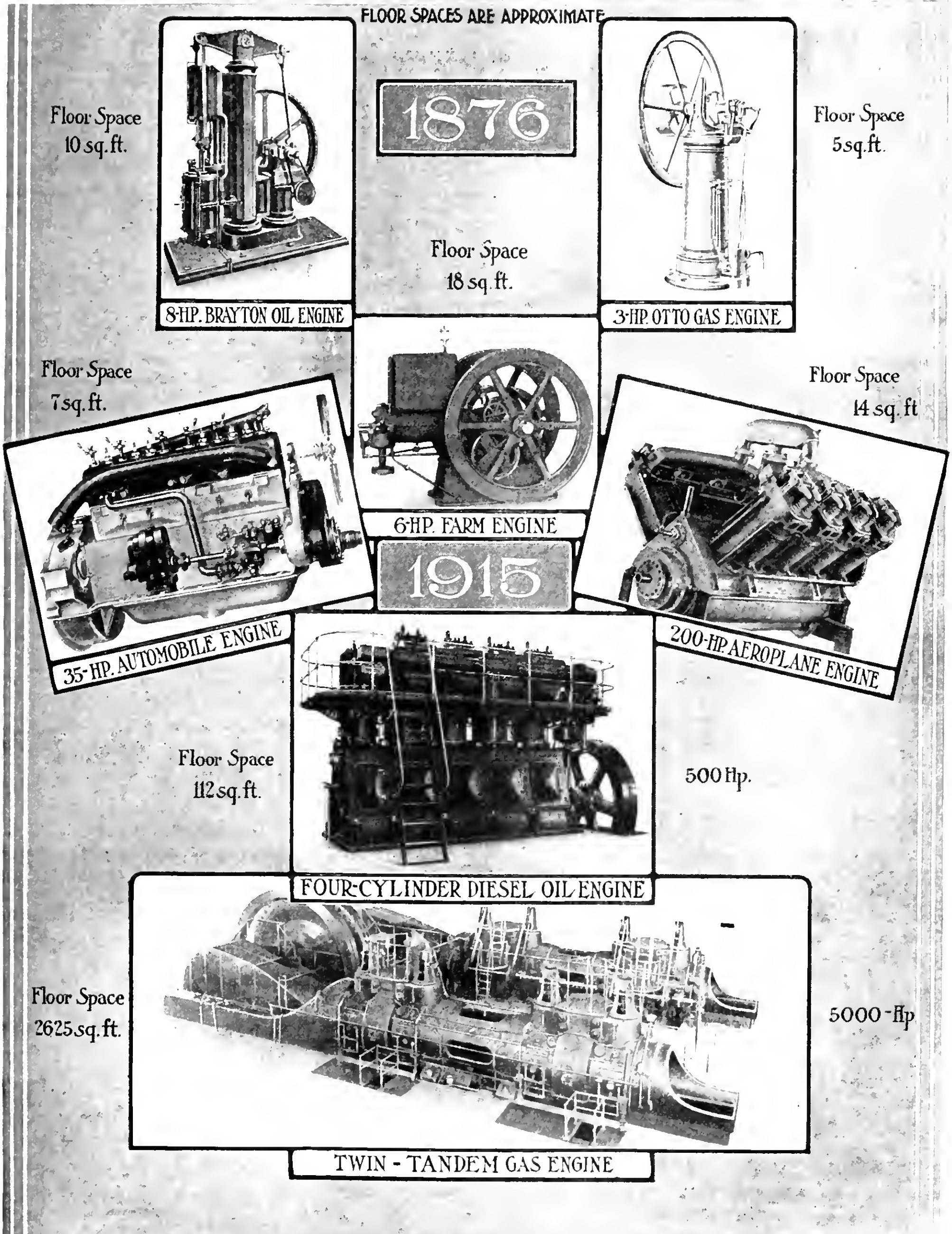
Type	Cylinders	Horsepower	Weight	Weight per Horsepower	Fuel Consumption
Otto	Single, single-acting, 9 in. x 5 ft. 10 in.	3			28 cu.ft. coal gas per hp.-hr.
Brayton	Double, tandem, vertical, 6x9-in.	8			About 2 lb. per hp.-hr.; oil of 0.85 sp.gr.
Automobile	6-cycle, 3½x5-in.	35 hp. at 1800 r.p.m.	500 lb.	14.5 lb.	
Aeroplane	8-cyl., 5x7-in.	200 hp. at 1700 r.p.m.	650 lb.	3¼ lb.	0.1 gal. per hp.-hr.
Farm	Single	6 hp. at 350 r.p.m.	1550 lb.	258 lb.	
Blast-furnace gas	Twin-tandem, 44x60 in.	5000 hp. at 83⅓ r.p.m.	1,900,000 lb.	380 lb.	
Diesel	4-cyl., 19x24½-in.	500 hp. at 200 r.p.m.	181,000 lb.	362 lb.	0.408 lb. per hp.-hr.

The automobile has been responsible for the development of the gasoline engine to a high state of perfection during the past ten years, the motor shown representing one of the standard makes. In accordance with the latest practice, this is a long-stroke, high-speed type with cylinders cast *en bloc,* and weighs only 14½ lb. per horsepower.

Since the practical application of the aëroplane followed closely that of the automobile, the experience with the latter was invaluable in the design of a motor for the former. The departures were essentially in the reduction of weight, increase of power and provision for continued operation at maximum load. The engine shown represents one of the most successful American designs, in which the weight has been reduced to 3¼ lb. per horsepower and the fuel consumption to 0.1 gal. per horsepower-hour—another vital point in aëroplane work.

The farm engine, on the other hand, had been developed with a view to ruggedness and foolproof operation, with fair economy and little attention to weight. The

EVOLUTION of the INTERNAL-COMBUSTION ENGINE



6-hp. engine shown, which is representative, weighs two and one-half times that of the 200-hp. aëroplane motor and three times that of the 35-hp. automobile motor.

The 5000-hp. gas engine is one of a number of similar units operating on blast-furnace gas and driving generators and blowers at the Gary plant of the U. S. Steel Corporation, and represents one of the largest of its kind now in operation in this country. Owing to the size of the cylinders, 44x60 in., and the pressures involved, the construction is necessarily heavy, and it is probable that 5000 hp. will be about the limit for engines of this type.

Just as the Otto engine was the pioneer in the gas-engine field, so was the Brayton in the oil-engine field. It needed, however, the genius of Dr. Diesel and the untiring efforts of the manufacturers who took up his patents to produce what is today the most highly efficient heat engine in existence. To obtain this economy extremely high working pressures are required—500 to 600 lb. per square inch as compared with 50 lb. in the Otto and slightly more in the Brayton. This necessitates heavy construction, the engine shown, which is one of American make that is being exhibited at the Panama-Pacific Exposition, weighing 362 lb. per horsepower.

Firing Low-Grade Fuel and Wastes

By Sterling H. Bunnell

Much has been done toward operating steam-boiler furnaces on wastes of various plants, in utilizing slack and culm or coal-mine wastes and in developing power from city garbage. The question of economy is of first importance in deciding whether or not a low-grade fuel should be used. There are three elements to be considered; namely, the quantity of heat which can be produced per pound of fuel, the efficiency with which this heat can be transmitted to the boiler, and the cost of the fuel put into the furnace. Coal at $3 per ton delivered at the fire room and having a heat value of 10,000 B.t.u. per pound and fired in a furnace under conditions which give 70 per cent. boiler efficiency, must be fired at the rate of 10,000 divided by 0.70, or 14,300 B.t.u. of coal to put 10,000 B.t.u. under the boiler; and as 2000 times 10,000 B.t.u. cost 300c., the cost of 14,300 is 0.214c. Assuming that it costs 30c. to fire a ton of this coal, the cost of the coal in the furnace should be increased by $\frac{30}{300}$, or $\frac{1}{10}$, making 0.235c. to put 10,000 B.t.u. into the boiler.

In comparison with this coal, suppose a fuel to be obtainable at 50c. per ton, giving only 4000 B.t.u. heat value per pound and capable of being fired with a boiler efficiency of 50 per cent. The computation shows 20,000 B.t.u. required to put 10,000 B.t.u. into the boiler; so, as 8,000,000 B.t.u. cost 50c., 20,000 will cost $\frac{1}{8}$c. If this fuel costs 50c. per ton to fire, it will be necessary to add $\frac{50}{50}$, or 100 per cent. to obtain the cost of 10,000 B.t.u., making the amount 0.25c. There is no money in firing this fuel under these conditions, as the cost is slightly more than the cost of good coal. It would, however, be desirable to use the low-grade fuel if it were a waste accumulating like sawdust and wood refuse in wood-working factories, in which case it would cost less to burn it than to cart it away. If the value of the fuel were 6000 B.t.u. per pound instead of 4000, it would figure $\frac{1}{12}$c. for fuel and the same for firing, making 0.166c. for 10,000 heat units delivered to the boiler as compared to 0.235c. for the coal at $3 per ton.

In every case it is important to consider all the conditions in connection with the various fuels which can be obtained, not forgetting that good coal can be fired by average firemen, while low-grade waste requires special skill to handle it successfully.

The mechanical difficulties in burning low-grade fuel are important and must be met by special construction and firing methods. Fine coal and dust tend to fall through the grates, no matter how small the openings are made. These fuels also tend to pack together, making a strong draft necessary to force air through the fire. Agricultural wastes, like spent tan bark, often contain a weight of water equal to or greater than the combustible. It costs as much to evaporate water in the fuel as in the boiler.

The draft for burning most kinds of low-grade fuel should be strong. The worst and wettest garbage is successfully burned in furnaces supplied with forced ashpit draft under pressures of 2 in. and more of water. If means can be provided to heat the air before entering the ashpit, by using waste heat from the flue gases, the combustion in the furnace is improved. The moisture content of the fuel should be reduced as much as possible. Sometimes this advantage can be gained by a change in the mechanical operation producing the waste. If not, it is usually necessary to fire the fuel as it comes, regardless of the quantity of water it may contain, as fuel-drying operations on a large scale are practically impossible. One instance to the contrary, however, is the burning of sewage sludge, which is first dried by passing it through a rotary drier in which hot flue gases circulate. Sewage sludge, however, has no heat value, and is burned merely to dispose of it without nuisance.

With most materials containing much moisture the drying must take place in the furnace and this requires careful watching and stoking. Sometimes a drying hearth can be provided on which the wet fuel can be first charged and allowed to dry in the direct heat of the fire. It is important to observe that the fuel must not be burned faster than it can be dried, or the fire will soon be blocked and extinguished by wet material. The fireman must, therefore, manage to keep a brightly burning fire of dried fuel and to supply wet fuel so that most of the moisture will dry off before the fresh material is charged on to the burning surface.

A common difficulty with low-grade fuel, particularly coal waste and the rubbish from cities, is the presence of mineral matter which forms clinker. With good coal the proportion of noncombustible substance amounts to only a small percentage, not enough to form very bad clinker. Factory ashes from well handled fires contain only a small fraction of unburned carbon and are finely divided into small particles. From the average house furnace, however, the ash contains one-half or more of combustible carbon. Such ash, fired in a suitable furnace with forced draft, would be of commercial value. As the combustible portions of low-grade fuel burn away, the areas of worthless ash and clinker remaining become larger. The melting clinker tends to inclose particles of unburned coal and prevent air from reaching it. With all low-grade fuels, therefore, the fire must be carefully watched, and the free passage of air through it must be maintained by stoking, and breaking up areas where combustion is giving out from lack of accessible fuel.

Editorials

Flywheel Explosions

In the power plant the boiler is commonly regarded as the most dangerous part of the entire equipment. Probably nine out of every ten engineers are of this opinion, and it is not surprising, as the number of boiler explosions in this country is excessive, the casualty list is large and the value of property destroyed is greater by far than in other lands, where rules for safety are more rigidly and uniformly enforced. From people who should know, however—men dealing every day in power-plant accidents—comes the surprising information that the flywheel is more dangerous than the boiler. In other words, the ratio of flywheel explosions to the number of flywheels installed is greater by one-third than that for boilers. This does not refer to totals, as boiler explosions would then have the lead by a large margin, owing to the greater number of boilers installed.

Viewing power-plant safety from this standpoint, it is evident that more attention is due the flywheel. Every boiler has its safety valve, and if statistics are of any value every flywheel should have at least equivalent protection.

The potential energy stored in the flywheel is tremendous, although, owing to the swift and even turning, appearances are to the contrary. There is no indication of danger, and as a result, proper precautions are not often taken. The rim velocity of an average flywheel is close to a mile a minute and it is seldom that a wheel explodes at a velocity lower than three miles per minute, or 264 ft. per second. The damage that might ensue from the heavy pieces of disrupted wheel moving at this terrific velocity may, perhaps, be imagined. Numerous articles in the past have recounted the actual results.

Property damage, however, is only a minor consideration when compared to the safety of employees. For every flywheel explosion the average is one man killed or injured, and the toll for the year is so heavy as to warrant every precaution which will tend to prevent these accidents.

The function of the governor is to control the speed of the engine and with it the flywheel. Usually, there is also included a safety provision to guard against emergencies, but this is a secondary consideration in the design, and there are certain contingencies which it will not take care of. With this single protection against accident, derangement of the valve gear or failure in the governor's own mechanism may result in disaster. An independent device is needed to make safety doubly sure, and this device is the safety stop.

When the engine reaches a predetermined speed, the stop automatically shuts off the steam and relieves the engineer of the dangerous task of trying to close the throttle under emergency conditions. If the governor fails to work, the stop is on guard to prevent destruction. In military circles the secret of success lies in a strong reserve to supplement and reinforce the first line. In the engine room the stop occupies the same position. It is ready to come to the rescue of the governor, and if kept in good working condition it will reduce the number of accidents and afford added protection to the engineer.

Neglecting the damage to property and the interruption of service usually resulting from a flywheel explosion, the device is warranted from the standpoint of safety. At best, power-plant work is dangerous and there are few places in which the "safety-first" slogan is more urgent. The life of at least one engineer every week is surely worth saving, and if the installation of safety stops will effect even a small reduction in the fatalities, there is not a power plant in the country which should not have one. It is due the engineer, and incidentally, the reduction of property loss may be worth while to the owner.

Compulsory Boiler Inspection

In most of these United States a man may buy any old kind of a boiler that he wants to, new or second-hand, have it set up by the local plumber, hire the hunk to run it who will do it for the least money, and put any amount of pressure upon it that he sees fit.

It may be said that ordinary business prudence and fear of damage to himself and his own people and property would preclude a man from taking too long chances; but any government or insurance inspector can tell of numbers of death traps set by the cupidity or, in justice be it said, more often by the ignorance of the boiler user.

Last year the inspectors of the Hartford Steam Boiler Inspection & Insurance Co. condemned outright 756 boilers as unsafe to use, and pointed out 23,012 defects involving the safety of the boiler.

In the same time the inspectors of the Fidelity & Casualty Co., of New York, condemned outright 340 boilers and pointed out 11,130 serious defects.

This, after the boilers had been prepared for inspection by the agents of their owners. These are only two, but the largest two, of a number of companies carrying boiler insurance. There are nine such companies doing business in Massachusetts.

Is it not reasonable to suppose that, if these boilers had not been inspected by specialists, there would have been a considerable addition to the loss of life and property by boiler explosions?

It is true that boilers which have been insured and inspected have exploded. Inspectors are human and fallible. They may overlook obvious faults, and there are hidden cracks in lap seams and flanges which the best of them could not detect; but this is no reason for condemning the whole system and renouncing the good which they are doing.

If the inspection incidental to insurance has revealed this number of serious defects, why would not an equally thorough and efficient inspection of uninsured boilers reveal an equally large proportion of defects and obviate an equally large proportion of explosions?

Are the boilers whose owners take a chance apt to be better selected, installed and operated than those whose owners take the precaution to insure them?

In Massachusetts 17.969 boilers are inspected by the insurance companies. The state inspects the rest of them, 6723, itself. This is what all the states ought to do. Public safety ought not to be left to the "ordinary business prudence" of any man in the matter of boilers more than in storing and using gasoline or explosives.

A boiler full of hot water under pressure is just as dangerous under a sidewalk or a building as a keg of gunpowder.

The necessity of governmental regulation seems too obvious to question. Everybody does it but us.

Safety-Valve Capacity

One of the hardest nuts which the American Society of Mechanical Engineers' committee, while preparing the standard boiler code, had to crack was the question of safety-valve capacity. Previous to the last annual meeting the manufacturers of safety valves got together and said: "Now, let us go at this thing scientifically. What has a safety valve to discharge?"

"Steam."

"How much steam?"

"As much as the boiler can make—and then some."

"How much can the boiler make?"

"Ah! that depends upon the boiler, and the furnace, and the fuel, and the air supply, etc. But if we take the heat value per pound of the fuel and multiply that by the number of pounds which can be burned under the boiler per hour, multiply that again by the combined efficiency of the boiler, furnace and grate, and divide the product by the difference between the total heat per pound of steam as made and the heat per pound in the feed water, we shall find the amount of steam made per hour. Then we can give them a table of the discharge capacities of our valves of different sizes, and they can tell right away how many valves, of what size, it will take to discharge this amount of steam."

But the discharge capacity of a valve depends upon its lift, and there are makers who believe in high lifts and those who do not. After long discussion the valve manufacturers agreed unanimously upon the table of capacities which appeared in the third and fourth reprintings of the tentative report of the committee.

The proposed method evoked storms of protest. The conception of the country pipe fitter struggling with the B.t.u. per pound of fuel, the heat of the liquid and of evaporation, and the possible effect of draft on rate of combustion, was a little too much. The government and insurance inspectors vowed that it would take longer to inspect the safety valve than it would the boiler.

The question was therefore turned back at the safety-valve men, and they, unable again to meet upon a common ground as to a standard rate of discharge for safety valves, have presented a table giving the discharge in pounds per hour at minimum, intermediate and maximum lifts. The three-inch valve of no manufacturer shall lift less than five-hundredths nor more than one-tenth of an inch at one hundred pounds gage, and it is guaranteed to discharge certain amounts per hour at each of these lifts and the average of them.

At its rated capacity a boiler is expected to evaporate about three pounds of water per square foot of heating surface. In some of the large stations they are evaporating ten or more. If it be assumed that any boiler may possibly be subjected to this rate of evaporation some time in its life, and the amount of steam to be provided for by the safety valve be assumed at ten times the number of square feet of heating surface, the calculation would become an extremely simple one. A boiler having one hundred square feet of heating surface might possibly be subjected to conditions under which it would evaporate ten thousand pounds of steam per hour, and to discharge this would, by the table submitted, require one four-and-one-half-inch or two three-inch valves, at one hundred and fifty pounds gage pressure.

This gives somewhat more valve area than is common in ordinary practice, and ordinary practice seems to be good enough, for we never knew of a boiler which exploded for want of safety-valve capacity when the safety valve was operative at all. The modern high rate of combustion is provoked and intentional, and can be attained only purposely by well managed fires urged by artificial draft. A boiler even in the heart of a conflagration would not accidentally do as much. A smaller though somewhat less convenient factor than ten would doubtless have to be used, but it would seem that the heating surface is the logical measure of the safety-valve capacity. The grate area may be changed from time to time, oil or gas may be used, the boiler may simmer under a natural draft or fume under the action of a blower, the fuel may vary from wet tanbark to oil or natural gas, but the number of square feet of heating surface is always the same, and if the boiler is provided with safety-valve area to take care of all the steam which that heating surface can generate, it will make no difference who gets the boiler or what he does with it, as far as this phase of the question is concerned.

Committee work in engineering organizations is usually hard, tedious and trying, but the fellow who never did any is the one who most loudly proclaims that it's a sinecure.

Beats all how some engineers can go through most of their lives telling themselves they do not need to keep studying the progress of their calling, and then suddenly become most enthusiastic over engineering educational work. In nine cases out of ten you will find that the change of front is due to the central station making a strong bid for their jobs.

Several inquiries have come to us regarding the decision of the American Manufacturing Company, of Greenpoint, L. I., to discontinue running its power plant and to purchase power from the Brooklyn Edison Company. It would seem that the amount of power here used could be generated on the spot more cheaply than a public service company could furnish it, and we sought an interview with the officials of the company for the purpose of learning, if possible, the facts which led to the decision. The only statement which was forthcoming was that it had been made to the advantage of the American Manufacturing Company to purchase its current from the Brooklyn Edison Company and that there was nothing to discuss regarding comparative costs. The mere cost of production is not always the controlling factor in the interrelations of Big Business.

Correspondence

Transformer Connections

After reading Mr. Fox's article on transformer connections in the issue of Jan. 12, I feel that although his process of testing the polarity of transformers and grouping them to obtain various results is instructive, it could be somewhat improved by adding a simplified method for remembering the various connections and ways for determining when the devices are connected properly.

The opinion seems to exist among practical electricians with a limited knowledge of electrical theory, that there is one particular kind of parallel and series connections for batteries and some other kind for transformers or other devices; but this is not true, as there is one hard and fast rule that applies to all. When batteries are connected in parallel all positive terminals are connected together, likewise all negative terminals, and then a positive and a negative lead are brought out from the group as indicated in Fig. 1. What is true for this is also true for any other electrical device, from which the rule for parallel connection may be obtained, namely, connect like poles to like poles and bring out two unlike leads.

In connecting batteries in series a positive terminal is connected to a negative terminal until all are connected except one negative and one positive; these two are connected to the device to be operated. This is indicated in Fig. 2 and is true for any device, from which the law for series connections is obtained, namely, connect unlike poles until but two remain unconnected; bring these two out to the load.

When transformers are connected in parallel or series it is first necessary to determine which are like poles. After the transformers have been set symmetrically, consider all right-hand terminals of one polarity, say positive, and all left-hand terminals of the opposite polarity; then proceed as though connecting batteries, as indicated in Fig. 3, which shows two transformers connected in parallel. By comparison with Fig. 1 it will be seen that the grouping is similar. There is always a chance of the leads being brought out of the transformers to give the wrong polarity, and to guard against a short-circuit, connect a piece of two- or three-ampere fuse-wire in the low-voltage side as shown at *f*, Fig. 3. Then close the primary circuit with the secondary disconnected from the load, and if the connections are correct the fuse will not blow.

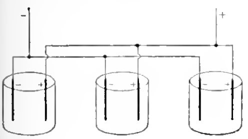


FIG. 1.

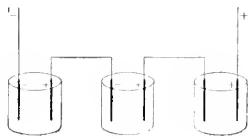


FIG. 2.

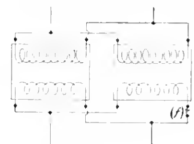


FIG. 3.

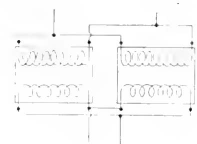


FIG 4

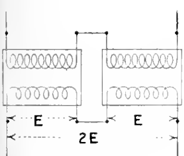


FIG. 5.

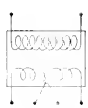


FIG 6.

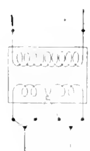


FIG. 7.

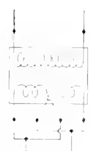


FIG. 8.

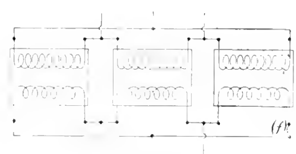


FIG. 9.

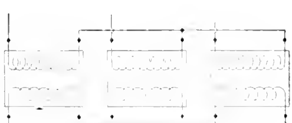


FIG. 10.

CONNECTIONS OF TRANSFORMERS

If the fuse blows, cross either the primary or the secondary leads of one transformer as in Fig. 4; this will correct the defect, irrespective of which transformer had the wrong polarity. A test lamp or voltmeter may be used in place of the fuse. If the connections are correct the lamp should not light nor the voltmeter read. The fuse, however, is not only the most likely to be at hand, but is also the most reliable, as there is always a chance of a defective lamp or instrument.

When transformers are connected in series the same rule is followed as in batteries, and by comparing Fig. 5 with Fig. 2 it will be seen that the same relation of connections is maintained in both cases. However, if the leads are brought out of one transformer to give the wrong polarity, the proper voltage relation will not be obtained on the secondary side, which should be as indicated, and instead of the voltage being 2E between the two outside terminals, it will be zero. This can be remedied by crossing the secondary or primary leads on one of the transformers.

There are usually four leads brought out on the low-voltage side of all small commercial transformers; the two center leads being brought out crossed as in Fig. 6. This brings the like terminals of each coil adjacent to each other and eliminates crossing them on the outside when the coils are connected in parallel as shown in Fig.

7. Care should be taken not to connect the two terminals of each coil together as in Fig. 8, for this would be a dead short-circuit.

It may be easy for those familiar with the laws of graphics and alternating currents to depend upon connecting transformers so that they form an angle of 60 or 120 electrical degrees to each other to obtain a delta or star-connection on a three-phase circuit; but for the man that does not possess this knowledge, the fact that the delta connection, as far as the grouping is concerned, is nothing more than a short-circuited series connection should greatly simplify the matter, as will be understood by referring to Fig. 9. The three transformers are connected in series as are the batteries in Fig. 2, but instead of bringing out the two outside terminals to the load as in the battery connections, they are connected together to form a complete loop with a lead brought out from each junction point. To make sure that the connections have been made properly and the transformers are all the same polarity connect a piece of fuse wire as at *f*; if the fuse does not blow the connections are correct and the transformers are of the proper polarity.

The making of a star connection may be greatly simplified if it is remembered that like terminals of the transformers are connected together (it may be either the right-hand or the left-hand terminal) and the other three terminals are brought out to the line as in Fig. 10, which shows the three right-hand terminals connected, with the three left-hand ones brought out to the line.

A. A. Fredericks.

New York City.

Boiler Explosion at Menlo, Iowa

A disastrous boiler explosion occurred at the electric-light plant at Menlo, Iowa, shortly after 6 p.m., Feb. 14, killing three men instantly and completely demolishing the power house.

The boiler was of the return-tubular type, of 60-hp.

Fig. 1. Wreckage after Boiler Explosion

capacity. The safety valve was set at 95 lb. The rupture occurred in the rear sheet, which ripped entirely around where it joined the middle sheet, and was thrown a distance of about 300 ft., breaking a number of telegraph lines in its descent. The rear flue sheet was thrown a distance of 600 ft., and fell through the roof of a dwelling shown in Fig. 2 and landed in the kitchen. A heavy stop valve fell in the yard of the same residence. As the explosion occurred at the supper hour, the occupants of the house were seated at the table in an adjoining room and no one was injured.

The power house stood some distance from other buildings and being constructed of heavy concrete, the injury to the surrounding property was slight, consisting of some damage to roofs due to falling pipes, brick, etc. The heavy concrete walls, together with the fact that the boiler was set below the ground line, undoubtedly prevented much damage to the adjoining property.

No definite cause is known for the explosion, as all those who might know were killed. The boiler was about 18 years old and fairly clean and free from scale. The men were evidently sitting directly in front of the boiler, judging from the position in which the bodies were found.

Fig. 2. The Tube Sheet. Fig. 3. The Rear Circular Sheet Near Railway Track. Fig. 4. Close View of Pitted Sheet

Had the accident occurred a few minutes later it is likely the loss of life would have been much greater, as it was the custom of a number of the employees and others to spend some time at the plant after the supper hour.

S. Kirlin.

Stuart, Iowa.

[Figs. 2, 3 and 4 were received later from J. C. Bruff, Atlantic, Iowa, without additional information as to the probable cause of the explosion.—Editor.]

Some Reasons for Different Rates

There appears to be a prevalent idea that central stations sell power below cost to large consumers and make up the loss by charging the small ones high rates. It doesn't seem to occur to some of these people, however, that if this were true it would be a wise policy to cut out the large consumer and make a still larger profit.

The average power company has a scale of many different rates to cover different conditions, and the writer will attempt to explain the reason for some of them. To make the explanation more simple, he will compare the product and sale of electricity to ice. Let the square figure represent a pond with a crop of ice. Jones, the iceman, builds up a trade from house to house to sell in lots of 50 to 100 lb. daily from his wagon and will cut the area marked *A*. He also looks over the grocery and provision markets that will take 200 to 500 lb. daily and estimates that the area marked *B* will supply them. There is likewise a large demand from the ice-cream factories and soda fountains, each of which will require 1000 to 2000 lb. per day, and he secures that business, requiring him to cut area marked *C*.

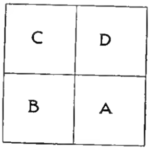


Diagram Representing Pond

In the town where Jones does business Smith and Brown have small icehouses which are badly in need of repair, and it occurs to them that Jones can harvest the balance, or area marked *D*, cheaper than they could harvest their own, so they arrange to take that amount from Jones. To harvest ice marked *A*.

Cost of labor per ton	$1.00
Cost of machinery, house and other equipment per ton	1.50
Total cost per ton	$2.50

To harvest *B*, in addition, will require another story on the icehouse and the labor will be more efficient, making

Cost of labor per ton	$0.85
Cost of machinery, house and other equipment per ton	0.85
Total cost per ton	$1.70

To harvest *C*, in addition, will require another story on the icehouse and the labor will continue to become still more efficient, making

Cost of labor per ton	$0.75
Cost of machinery, house and other equipment per ton	0.60
Total cost per ton	$1.35

To harvest *D* will require another story on the icehouse, still using the same machinery as at first, and there will be a slight improvement in labor, making

Cost of labor per ton	$0.70
Cost of machinery, house and other equipment per ton	0.45
Total cost per ton	$1.15

Leave out the shrinkage and other losses before summer and consider the delivery.

A two-horse team is worth $5 per day and two men will cost about $5 more, making $10. These will make two trips per day, delivering one ton per trip to householders taking 50 to 100 lb. of ice. The usual rate to consumers of small quantities is about $8 per ton, so it is easy to figure the profits:

Two tons at $8 per ton		$16.00
Cost of two tons at $1.15	$2.30	
Cost of team	5.00	
Cost of two men	5.00	
		12.30
Gross profit		$3.70

The rate to markets which take 200 to 500 lb. may be $6 per ton, and a similar team would make three trips per day, or deliver three tons, the profit working out as follows:

Three tons at $6 per ton		$18.00
Cost of three tons at $1.15	$3.45	
Cost of team	5.00	
Cost of two men	5.00	
		13.45
Gross profit		$4.55

The rate to ice-cream factories and soda fountains, which take 1000 to 2000 lb. at a time, and allowing the team to make five trips daily, may be $4 per ton, working out as follows:

Five tons at $4 per ton		$20.00
Cost of five tons at $1.15	$5.75	
Cost of team	5.00	
Cost of two men	5.00	
		15.75
Gross profit		$4.25

Now Smith and Brown have arranged to take their own ice from the house, using about ten tons each per day, and Jones made them the ridiculous price of $2 per ton; but the profit comes out as follows:

10 tons of ice at $2	$20.00
Cost of 10 tons at $1.15	11.50
Gross profit	$8.50

It is evident that Jones cut down his cost by harvesting the whole field, and if he had stopped at *A* he would have had to charge at least $10 per ton to householders, to make a reasonable profit.

On the other hand, he could not charge the markets, ice-cream factories and Smith and Brown (whose business caused the whole lot to be cheaper) the same price as the householder for two good reasons—he couldn't get the business, and if he did the profits would be unreasonable.

If Jones found it necessary to give up part of his business and had his choice, which part would he drop?

CHARLES R. SEED.

Worcester, Mass.

Oil-Engine Tendencies

In the Feb. 9 issue, under the heading "Oil Engine Tendencies," Mr. Ward makes a number of statements to which I wish to take vigorous exception, based on many years of work on this subject.

Oil-Fuel Situation

Mr. Ward states that, since petroleum is composed of 15 per cent. gasoline, 15 per cent. kerosene, 10 per cent. high-grade distillate above 39 deg. Baumé, 10 per cent. low-grade distillate below 39 deg. Baumé, 15 per cent. lubricating oils and a remainder of 5 per cent. "slop," not over 10 per cent. is of such a nature as to require a crude-oil engine to utilize it. In Mexico, for instance, there is much oil which is of an asphaltic base and so low in volatile or refinable products as to be practically valueless for refining. The oil to which Mr. Ward referred was evidently of a paraffin base, which constitutes less than half the oil supply. If I am correct, over 60 per cent. of the raw product as drawn from the wells is available only for use in the heavy-oil engine, for generating steam, etc.

Semi-Diesel Type

It is further stated in the article that by changing from 500 to 300 lb. compression, the fuel does not burn immediately upon entering the combustion space, as the heat of compression is insufficient to ignite it. I have demonstrated that for a running engine 150 lb. is sufficient to ignite the fuel,* the hot plate being needed only for starting in the engine which I have developed. Mr. Ward says that the semi-Diesel type should be built as heavy as the regular Diesel; further, that the maximum pressure in the semi-Diesel is 500 lb. The Diesel must have a relief valve set at from 750 to 800 lb., indicating that the pressure frequently runs to 800 lb., whereas the semi-Diesel pressures do not run over 500 lb. According to this the semi-Diesel need be built only five-eighths as strong as the Diesel. The writer's experiments would tend to indicate that an oil engine can be built which need be but little heavier or stronger than the conventional gas engine.

Two-Stroke-Cycle Type, Fuel Injection and Hot Bulb

Of these points I have little to say, except to voice the opinion that the two-stroke-cycle type can be beaten on every point by the four-stroke-cycle type. The fuel injection is still very crude and is only slightly developed from what Brayton disclosed in 1890. It seems possible to greatly improve upon the present arrangements, but my experiments along this line as yet are incomplete. Hot bulbs seem to be uncalled for and are not very practical for large sizes.

Water Injection

This is the weakest point in the semi-Diesel type. Mr. Ward says that a pressure of 300 lb. is not sufficient to ignite the fuel, and yet he mentions the use of water injection in order to keep the temperature of compression within bounds. The use of water from a thermodynamic point is as wise as it would be to propose to govern an engine by an automatic brake that would absorb the unneeded power and in this way regulate the speed of the engine. Provided the engine can first be started, the Brayton fuel injection can be used on the semi-Diesel type and the waste from the water injection can thus be avoided.

Lubrication

The writer fails to see any problem in the lubrication of the oil engine not met in the gas engine. The jacket should be used to keep the temperature at a point which is reasonably below the safe line. To go below this point is wasteful; to go above it is dangerous.

The writer got into a controversy with an engineer in the employ of the original Diesel Engine Co. of America in 1904. The point was the maximum temperature in the engine, which at that time was taken to be the temperature of compression. Temperature calculations were made from a Diesel diagram and submitted to the company. The answer was that the engine worked and that was all that the firm was interested in. The writer was interested, however, and as a result of this lack of interest on the part of the oil-engine men concerning their engine, has been able to be the first applicant in the U. S. Patent Office on many lines of development of the oil engine. There is a thermodynamics of the steam engine. In the gas engine one is limited by premature explosion, in the amount of compression carried. In the Diesel, owing to starting troubles, one is limited in the minimum compression on account of lack of ignition. The oil engine, once it is started or warmed up, can be operated on any pressure from, say 125 lb. up. The best method for getting the oil engine into a condition to avail itself of this low pressure of compression depends upon the use of the engine. For large engines there can be no better method in the opinion of the writer than to follow the practice of the steam engineers, namely, that of warming up their engines by the introduction of steam into the jackets.

John F. Wentworth.

Quincy, Mass.

*See paper by the writer presented before the last meeting of the Society of Naval Architects; also abstract of same in "Power," Jan. 26, 1915

Driving Boilers and Bursting Tubes

Referring to the discussion of the above subject which was started by the picture and story of a burst boiler tube given in the Dec. 8, 1914, issue, page 805, the editorial comment on page 95, Jan. 19, 1915, is correct in stating that increasing the furnace heat increases the evaporation. However, Mr. Kent is right in saying that there may be times when the heat will be greater, as when the steam gets low and it becomes necessary to regain the pressure; the heat must be increased and also the evaporation, but the average evaporation remains the same.

The temperature of the water in the tube has nothing to do with overheating the tube, for the water, either hot or cold, will take up all of the heat that can be forced through the insulation of oil or scale in the tube.

The pressure has a great deal to do with the bursting of the tube, as it will require more overheating to burst the tube at low pressure than it will at high pressure.

Willis W. Nelson.

Spokane, Wash.

Trouble with Oil Separator

Referring to the query by H. G. Goodwin in the issue of Feb. 9, page 207, I would suggest that for a possible source of trouble he should examine his sewer connections. Referring to his sketch, we find that, as nearly as can be estimated, there is a difference of ten to twelve feet head in the two connections leading to the sewer. If the sewer connection is not adequate and is connected to other sources, it is possible that water backs up in the pipe leading to the oil separator in the basement until conditions allow the oil and exhaust steam to pass over into the heating system. This oil would naturally be carried into the heating system through the lower oil separator on account of the difference in head between the pipes leading from the two oil separators.

If such a condition existed the remedy would be to disconnect the exhaust from the 25-hp. engine in the basement and connect it with the same piping which leads from the 100-hp. engine on the first floor. This would remedy the trouble if the oil were passing into the heating system from the basement floor only. If oil then passed over and if the rain-leader connections from the building led into the same sewer, the remedy would be to run independent sewer connections from the oil separators and from the heating system.

W. R. Metz.

Washington, D. C.

Inquiries of General Interest

Chatter of Reducing Valve—What will cause a reducing valve to chatter?

E. H

A reducing valve is likely to chatter if the valve is large in proportion to the use of steam at the reduced pressure. In most cases the remedy for chattering is to throttle the supply or to throttle the valve which admits low-pressure steam to the diaphragm.

Advantages of Mechanical Stokers Burning Cheap Fuel—Why are mechanical stokers better adapted for burning the cheaper grades of fuel than hand firing?

G. M.

A mechanical stoker can usually handle a lower grade of fuel because it carries a cleaner fire, the coal is fed more uniformly and the air required for combustion can be supplied at a more uniform rate.

Percentage of Output for Excitation—What percentage of output of an alternating-current generator is required for excitation?

L. H.

The excitation of a generator will vary according to the load and the voltage, but, under normal conditions and rated load, will amount to from 1 to 2 per cent. of the generator output in large machines and slightly more in smaller machines.

Weight of Cast Iron, Wrought Iron and Steel—What is the weight per cubic inch of cast iron, wrought iron and steel?

G. L.

The weight of each varies with the texture and method of manufacture. The approximate mean values used in calculations are 0.2604 lb. for the weight per cubic inch of cast iron; 0.2779 lb. for wrought iron, and 0.2834 lb. for steel, but more commonly 0.26 lb. for cast iron and 0.28 lb. for both wrought iron and steel.

Heating of Conduits Containing Wires of Polyphase Circuit—When the wires of a polyphase circuit are put in separate conduits, instead of all in one conduit as is usually done, why is it that the conduits heat?

E. D.

The greater the distance between conductors of a polyphase circuit, the greater the induction set up between these conductors, hence, the greater the heating effect thus produced. Putting the conductors in the same conduit lessens the distance between them, thereby cutting down the induction and the heating effect.

Required R.p.m. to Develop 1000 Hp.—How many revolutions per minute would be required for development of 1000 hp. by a pair of hoisting engines having cylinders 30x60 in. and a mean effective pressure of 90 lb. per sq.in.?

W. C. R.

As 1000 hp. would represent a development of

$$33{,}000 \times 1000 = 33{,}000{,}000 \text{ ft.-lb.}$$

of work per minute and as one revolution of the engine would develop

$$90 \times (30 \times 30 \times 0.7854) \times {}^{60}/_{12} \times 4 = 1{,}272{,}348 \text{ ft.-lb.}$$

then for the development of 1000 hp. the engine would have to make

$$33{,}000{,}000 \div 1{,}272{,}348 = 25.93 \text{ r.p.m.}$$

Working Pressure for Old Boiler—Is resistance of a hydrostatic test pressure 50 per cent. in excess of the working pressure proposed for an old boiler sufficient for determining the safety of the boiler operated at the proposed working pressure?

A. B.

A hydrostatic test pressure would only determine whether the boiler would probably be tight for the proposed working pressure. The working pressure should be decided from computation of the safe working strength of parts, based upon internal and external inspection before and after the hydrostatic test, with due consideration of the condition of the material and previous kind and length of service of the boiler.

Higher Efficiency with Oil than with Coal Burning—Why are higher boiler efficiencies obtainable with oil burning than with coal burning?

W. E. C.

Oil burning can be conducted with admission of but little more air than that which is required for furnishing the oxygen actually necessary, the furnace doors need not be opened while the boiler is under steam, and the boiler surfaces are not so quickly fouled with soot. In coal burning, to obtain distribution of an adequate amount of oxygen for the perfect combustion of each atom of carbon in the coal, it is necessary to introduce sufficient air to contain about double the quantity of oxygen actually required by the combustion. Therefore, in oil burning there is less loss from excessive air supply and, consequently, higher efficiency.

Difference of Water Pressure from Difference of Temperature—What would be the difference in pressure per square inch of a column of water 4 ft. high at a temperature of 40 deg. F. and at 100 deg. F.?

G. W. L.

The weight of a cubic foot of water at 40 deg. F. is 62.42 and the pressure per square inch exerted by a column 4 ft. high would be

$$\frac{62.42}{144} \times 4 = 1.733 \text{ lb. per sq.in.}$$

and as the weight of a cubic foot at 100 deg. F. is 62.02 lb the pressure exerted by a 4-ft. column at the latter temperature would be

$$\frac{62.02}{144} \times 4 = 1.722 \text{ lb. per sq.in.}$$

and the difference of pressure would be

$$1.733 - 1.722 = 0.011 \text{ lb. per sq.in.}$$

Discharge of Steam to Vat—What will be the rate of discharge of steam at 100-lb. gage pressure from the open end of a 1-in. pipe into water contained in an open vat with the end of the pipe submerged about one foot?

W. E. P.

The rate of discharge can be approximately determined by the Napier formula for discharge of steam through an orifice into a pressure which is less than 58 per cent. of the initial absolute pressure, viz.:

$$W = \frac{A \cdot P}{70}$$

in which

W = Weight of steam discharged, pounds per second;
A = Area of orifice in square inches;
P = Absolute initial pressure,

according to which the discharge would be about

$$\frac{0.7854 \times (100 + 15)}{70} = 1.29 \text{ lb. of steam per second.}$$

Clattering Exhaust Valves—How can I stop the clattering noise of the exhaust valves of a noncondensing Corliss engine, which usually occurs when the engine is running light?

B. N.

The noise is probably due to the valves becoming unseated from expanding the steam below atmosphere, in which case the remedy would be to run the engine with lower initial pressure, obtained by carrying lower boiler pressure or by throttling, and thus secure higher terminal pressure. If it is not practicable to reduce the initial pressure, expansion below atmosphere can be prevented at small cost of economy by joining together the indicator connections of opposite ends of the cylinder and, having them throttled sufficiently to prevent bypassing of more steam than found barely necessary to prevent the clattering of the exhaust valves, by admission of only enough pressure from one end of the cylinder to the other to prevent expansion below atmosphere.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Commission Orders Reduction in Edison Rates

Following so closely upon Governor Whitman's investigation of the New York Public Service Commission as to imply a belated attempt to make good, the commission, after nearly four years of investigation and protracted hearings, has announced a decision in the Stadtlander case. By this the New York Edison Co. is ordered to reduce its maximum price of electricity from 10 to 8c. per kilowatt-hour. This reduction, if put in effect, will mean a saving of perhaps two million dollars annually to the large number of small consumers.

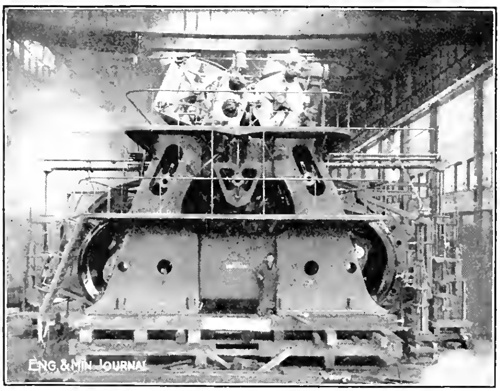
Commissioner Maltbie, who conducted the hearings, offered a resolution to reduce the price from 10 to 6½c. per kilowatt-hour, allowing the company to charge for the meters. This was voted down, 4 to 1, and Commissioner Williams' resolution for a reduction from 10 to 8c. was substituted. The former would have meant a greater saving to the large retail consumer, such as the storekeeper, but would hardly have favored the average householder as much as the recommendation adopted.

Just what action the Edison company will take in complying with the order is not known.

Large Compound Condensing Hoist

The largest compound condensing hoisting engine in the world was recently ordered by the Homestake Mining Co., and built by the Nordberg Manufacturing Co. It is of the duplex inclined cross-compound type, as shown by the side view. The two high-pressure cylinders are 28 in. in diameter and the two low-pressure 52 in., all with a common stroke of 42 in.

The hoist is built with two reels, each on a separate crankshaft. The reels are driven by axial plate clutches



NORDBERG COMPOUND CONDENSING HOISTING ENGINE

and equipped with gravity post brakes, air-operated. The hoist lifts 12,000 lb. net of ore per trip from a depth of 3200 ft. in a vertical shaft. The rope is ⅝x7¾ in., and the total rope pull is 41,900 lb.

The initial steam pressure is 150 lb. gage. All cylinders are steam-jacketed, and the exhaust pressure is maintained at 26-in. vacuum by a special design of counter-current jet condenser developed by Mr. Nordberg for hoisting-engine work. The circulating and dry-air pumps are direct-connected and driven by a simple Corliss engine.

The arrangement of this engine, having two main crankshafts connected with side rods and a reel mounted on each shaft, was necessary, owing to the topography of the ground around the shaft where this hoist is being installed. The only desirable location for the engine house bore such a relation to the shaft that the two ropes from the head sheaves to the hoist stand 12 in. center to center. With two ropes, each 7¾ in. wide and their centers 12 in. apart, it is obvious that it would be impossible to mount two reels on one shaft, as is commonly done.

The inclined cylinders and the relative position of the cranks are such as to give practically a uniform turning effort.

On small compound condensing hoisting engines working from depths of less than 1000 ft., the Nordberg company has obtained economies of less than 30 lb. of steam per shaft horsepower-hour, including the steam used by the condenser, and it is expected that the Homestake hoist will break all records for low cost of hoisting as soon as it is put in operation.—"Engineering & Mining Journal."

Unused Water Rights

What may well be helpful legislation is proposed by the Washington Water-Code Commission in a bill for the distribution of unused water rights in that state, and empowering the commonwealth to proceed by power of eminent domain to ascertain existing and proposed rights. The proposed law aims at more widespread use of the abundant waters and creates a new department under the direction of a hydraulic engineer who shall hold office for six years at an annual salary of $6000. Under the provisions of the bill an individual may exercise the power of eminent domain in the acquisition of water rights by petitioning the state which prosecutes the action in court and determines the rights of the parties.

It is urged in support of the bill that existing water titles are hazardous and that much of the water of the state is withdrawn from necessary use by the mixed condition of affairs. It is held that the state has enough unharnessed water power to furnish all the heat and power now generated by coal. Capital, it is urged, declines to develop water rights when titles are in the present precarious condition.

Extensive Water-Power Project at Millinocket, Maine

A dam fifty feet high that will flow the west branch of the Penobscot River back twenty-four miles and merge three lakes in one, is to be built this spring by the Great Northern Paper Co.

Before anything could be done toward the construction of this dam it was necessary to build a highway through the wilderness from the shore of Moosehead Lake to the gorge of Ripogenus, as in no other way could the cement and other materials be transported to the site. Two years have been occupied in building this road.

It is estimated that 40,000 to 60,000 horsepower can be developed at the gorge, but the dam is to be constructed primarily for the purpose of increasing the water-storage capacity of the west branch. The present storage capacity, estimated at 16,000,000,000 cu.ft., will be increased by the new dam to 21,000,000,000 cu.ft., while at Twin Lakes, some distance below, there has been created a storage of 15,000,000,000 cu.ft. Together, these storage basins will furnish a uniform flow throughout the year sufficient for the operation of the great pulp and paper mills at Millinocket and East Millinocket, where 1200 to 1500 men are employed and two thriving villages have grown up.

Connors Creek Plant of Detroit Edison

Before the Cleveland Engineering Society on Feb. 9, Prof. C. F. Hirshfeld gave an interesting talk on the new station now being erected by the Edison Illuminating Co., of Detroit. A brief abstract of the address follows:

A study of conditions indicated that a new plant would have to be installed and that economy and safety of distribution dictated a location about as far east of the business district as the older Delray plant is to the west of that district, with its heavy and concentrated loads. The Connors Creek site was finally selected as meeting this requirement as well as offering proper facilities for the receipt of coal and an adequate supply of circulating water.

One-third of the contemplated first plant on this site is now completed. The finished plant is designed to contain six 25,000-kv.-a. turbo-alternators and twelve 2365-hp. boilers similar to those now in use at Delray. It is probable that the turbo-alternators later installed may have greater capacity than those first contemplated.

Surface condensers, arranged for 35,000 sq.ft. of cooling surface, have been used. These condensers are so arranged that half of the tubes, with which the steam first comes in contact, contain cold circulating water. The circulating pumps are motor driven, and the air is withdrawn from the condenser by means of a motor-driven rotative dry vacuum pump arranged for two stages in one cylinder.

All auxiliaries, with the exception of the boiler-feed pumps, are electrically operated, the power being preferably taken from 1000-kw. turbo-alternators installed for that purpose. These small units and the boiler-feed pump turbines exhaust into heater condensers, the condensate from the main units being used as the circulating water for these condensers. The mixture of circulating water and condensed auxiliary steam serves as boiler feed. It is hoped that this arrangement will make possible the attainment of all of the advantages of electrically driven auxiliaries, together with the advantages accruing from the use of steam-driven auxiliaries.

Throughout the plant many innovations of a minor character have been introduced for the purpose of obtaining greater thermal and operative efficiency.

U. S. Geological Survey at the Panama Exposition

The exhibit of the United States Geological Survey at San Francisco occupies 62x78 ft. in the Palace of Mines and Metallurgy, flanked on one side by the display of the Bureau of Mines and on another by the Alaskan exhibit. The central feature is a booth, containing stage-like settings of a scene, partly modeled and partly painted. The first represents an undeveloped district in the arid West being studied by the Survey. Topographers, geologists and a stream gager are at work. The second scene shows the same district after development. The results of the stream gaging have been utilized in planning a power plant which shows in the distance and an irrigation project which covers the valley floor. A coal bed is being mined on one side; an oil field is under development elsewhere; a sandstone bed is being quarried in the foreground; mining and milling are in progress in the mountains; a town has been built, and roads, railroads and other evidences of civilization abound.

On recessed screens are shown pictures illustrating the different kinds of Survey work and the part they play in the development of the country. At one end of the space is shown the per capita production of minerals in the United States in 1880, about the time of the Centennial Exposition and of the organization of the Survey, and in 1913. A series of cases illustrate what our common things are made of, what the raw material looks like, and where it occurs in the United States; as examples, an aluminum saucepan, an electric-bulb filament and a fountain-pen point.

At the west end of the space is an exhibit of the power and fuel resources of the United States, including maps showing the distribution of the black shale from which oil is derived and the apparatus used in the field in determining the shales that are worth studying. In the portion of the exhibit relating to water resources is a display of automatic gages being run by clockwork and recording the fluctuating height of water in a tank.

Stereoscopic pictures will be arranged in boxes of fifty each, on a table at which one may sit and study various features of Survey work. There are also shown four series of pictures of the Grand Cañon and Rocky Mountain region, taken in the early days of the Geological Survey by the famous photographers, Jackson and Hillers. Other cases show the gem minerals, the rare mineral ores, etc.

Heating and Ventilation at the University of Illinois

The Department of Mechanical Engineering of the University of Illinois has been developing work along the lines of heating and ventilation, under the direction of Prof. A. C. Willard. A considerable amount of equipment for the experimental study of heating and ventilating problems has been installed within the last few months.

A recent addition consists of an air washer and humidifier specially arranged for experimental purposes. Complete control of the volume and temperature of the water circulation and of the air passing can be maintained. The washer is equipped with a double bank of spray nozzles which, by means of a finely divided mist, wash the air passing and also cool and humidify it. After passing the nozzles any entrained water in the air is removed as the air passes through a double row of V-shaped eliminators. The washer has a capacity of 3150 cu.ft. of air per minute at a velocity of 450 ft. per minute through the spray chamber. The spray water is circulated by a motor-driven centrifugal pump with a capacity of 30 gal. of water per minute at a discharge pressure of 25 lb. per sq.in.

When humidification is desired, it is necessary to saturate the air leaving the washer, and for this purpose a steam and water mixer of the injector type is installed in the tank below the spray chamber. The operation of this mixer is made to depend upon the temperature of the entrained spray water leaving the eliminator plates. A water-temperature regulator is placed in the path of the discharge from the eliminators, and this automatically operates a pneumatic diaphragm valve in the steam line leading to the mixer. Since the temperature of the saturated outgoing air and of the entrained spray water will be the same as they leave the eliminators, the regulator maintains a definite temperature of outgoing air of known humidity (100 per cent.).

The temperature of the outgoing air is also under the control of a duct thermostat which operates the pneumatic diaphragm valve supplying steam to a tempering coil placed in the inlet to the air washer. This coil makes it possible to preheat the air and determine the cooling effect or "humidifying efficiency" of the washer over a wide range of entering air temperatures. As an air washer or cleanser this apparatus is guaranteed to remove 98 per cent. of all solid matter contained in the entering air. The flow of air through the washer is induced by a multi-bladed fan with a 24-in. diameter rotor. This fan is driven through a transmission dynamometer by a variable-speed motor.

Reduction in Lighting Rates

In support of a bill to reduce residence-lighting rates from 6c. to 5c. per kilowatt hour, a schedule has been filed with the city council of Seattle of the earnings and profits of the municipal light and power plant, after having made reductions to 6c. per kilowatt hour, and a partial report of the net profits of the plant for the year 1914.

Since the beginning of 1911 the council has made four reductions in the residence-lighting schedule. About the middle of 1911 the rate was cut from 8½c. to 7c. and the minimum charge from $1 to 75c. per month, and in 1912 the rate was cut to 6c. and the minimum charge to 50c. per month.

Public Service Decisions

After careful examination by its engineers and accountants the New York Public Service Commission, Second District, has approved a method for the utilization of a large water power at Minetto, owned by the Columbia Mills, Inc., and to be leased to the Niagara, Lockport & Ontario Power Co. for use on its Syracuse and near-by lines, through the creation of a new company to develop the power. The stock of the new company, called the Northern New York Power Corporation, is to be taken by the Columbia Mills in part payment for its power. The bonds, interest and principal are also to be guaranteed by the Columbia Mills.

Though the Columbia Mills is a corporation organized under the business law, the Commission holds that, as it already sells a small amount of electricity to employees and other neighbors, it comes within the definition of an electrical corporation in the Public Service Commissions law, and as such its ownership of the stock of the other electric corporation must be approved by the Commission.

The Northern New York Power Corporation is authorized to issue $900,000 of its 6 per cent. first mortgage bonds at not less than 97 to net $873,000. Of this sum $350,000 is to be paid in cash to the Columbia Mills for its water rights, property, etc., and $455,000 is to go for the completion of the hydro-electric development. In addition, the power corporation is to issue $500,000 capital stock. This, at 125, is to be turned over to the Columbia Mills, in payment of the balance on the property transferred. The Commission further approves the lease of the new company's thus acquired and developed hydro-electric property to the Niagara, Lockport & Ontario Co.

The Commission has also approved a new link in the chain of power transmission lines in the northern part of the state, by approving franchises of the St. Lawrence Transmission Co. to extend its lines from Norfolk to Hannawa Falls, there to connect with the line of the Northern Power Co., and from Massena north to the Canadian border, where connection is made with the lines of the Cedar Rapids Transmission Co. of Canada, connecting the Cedar Rapids power with that at Hannawa Falls and elsewhere through the territory.

The Commission limits the use of these lines to transmission purposes only, through the villages of Norwood, Massena and Potsdam, and the towns of Pierrepont, Potsdam, Norfolk, Stockholm and Massena, for which the company holds franchises, but in which other local companies, such as the Norwood Electric Light & Power Co., are already doing a distributing business with the approval of the Commission.

OBITUARY

CHARLES A. SCHIEREN

Hon. Charles A. Schieren, millionaire philanthropist and once mayor of Brooklyn, died Mar. 10, of pneumonia. Mrs. Schieren, having contracted the same disease, died on the following day. Born in Rhenish Prussia in 1842, Mr. Schieren came to this country at the age of 14 with his parents, who settled in Brooklyn, N. Y. At first a cigar maker, in 1864 he went to work in the leather-belting factory of Philip F. Pasquay, in New York City. When his employer died in 1865, Mr. Schieren assumed the management of the concern and continued with the successors of the old firm until 1868, when he founded the firm of Charles A. Schieren & Co. The business grew steadily and numerous agencies were established in Europe, as well as in this country and Canada. In 1908 the Charles A. Schieren Co. was incorporated, and is today

CHARLES A. SCHIEREN

one of the greatest leather-belting concerns in the world, with factories at Ferry and Cliff St., New York City, and tanneries at Bristol, Tenn.

Mr. Schieren was chief organizer and vice-president of the Hide and Leather National Bank, president of the Germania Savings Bank and a director in the Nassau National Bank, Brooklyn Trust Co. and the Germania Life Insurance Co. He was a member of many clubs and was the chief organizer of the Brooklyn Academy of Music. During the Spanish-American War he was treasurer of the American Red Cross Society. In 1893 he was elected mayor of Brooklyn on the Republican ticket. He refused a renomination.

Mr. Schieren married Louise, daughter of George W. Bramm, in 1865. They had eight children, four of whom died. The living ones are Charles A., Jr., G. Arthur, Harry V. Schieren and Mrs. Albert H. Mathews.

PERSONALS

Prof. G. A. Goodenough, of the Department of Mechanical Engineering of the University of Illinois, recently gave a lecture on "The Development of the Steam Turbine" before the College of Engineering of the University of Wisconsin.

L. B. Marks and J. E. Woodwell, consulting engineers, 103 Park Ave., New York City, will dissolve partnership on May 1, 1915. Mr. Woodwell will locate at 8 West Fortieth St., where he will continue the general practice of consulting engineering, and Mr. Marks will remain at 103 Park Ave. and specialize, as heretofore, in illuminating engineering.

B. H. Bryant, civil engineer, has returned from Guatemala, Salvador and Honduras, where he had been locating railroad lines as chief locating engineer of the International Railways of America, and is taking a much needed vacation in Washington, D. C. Mr. Bryant, who has acted in the capacity of division engineer, chief engineer, construction engineer and general superintendent of steam railroads in the United States, Canada, Mexico, Brazil and South American countries for many years, is well known among railroad men. He expects to return to active work in the spring.

ENGINEERING AFFAIRS

National Association of Master Steam and Hot Water Fitters—The twenty-seventh annual convention of this association will be held at Milwaukee, Wis., June 21-24. It is suggested that those who contemplate going to the San Francisco Exposition can very nicely arrange to attend this convention and continue on their way to California, while those who expect to attend the convention of the National Association of Master Plumbers can leave at the close of this convention and reach San Francisco in time for the other.

NEW PUBLICATIONS

SANITARY REFRIGERATION AND ICE MAKING. By J. J. Cosgrove. Technical Book Publishing Co., Philadelphia, Penn., 1915. Size, 8½x6 in.; 331 pages, 45 tables; cloth. Price, $3.50.

The author has aimed to make the treatment graphical rather than mathematical and theoretical. To persons seeking an introduction to refrigeration and ice-making this book is one of the best that has come to our attention. It will also be a good book for many operating refrigerating engineers for it is well adapted to giving them the ground-work in theory that so many need. The first fifty pages are devoted to a simple treatment of heat. We cannot recommend the book to consulting refrigeration engineers, for, obviously, if it is adapted to the needs of the operating man it cannot be well suited to the consulting engineer. For the most part the book is descriptive of the systems of refrigeration, their applications, accessories and of ice-making systems.

GRAPHIC METHODS FOR PRESENTING FACTS. By Willard C. Brinton. Published by the Engineering Magazine Co., New York, 1914. Cloth, 7x10 in.; 371 pages. Price, $4.

The engineer has a well defined and a standardized method of representing objects. The blueprint "language" has a literature satisfying the simplest as well as the most complicated needs. But very little information is available regarding the best means of showing the relations between data by the difference in the length, size and direction of lines, areas and curves. Mr. Brinton's book, which is designed to serve as a handbook in the preparing of charts and the plotting of curves, is said to be the first dealing with methods of graphical presentation. That a great deal of the subject matter appeals primarily to nontechnical readers in itself makes the book valuable to the engineer illuminating data for a non-technical audience.

Some of the methods covered are the use of vertical and horizontal bars, the comparisons of objects by their size or number, map presentations, and organization and routing diagrams. The treatment of curves, described in six of the seventeen chapters, includes their general arrangement, the advantages of comparative, cumulative and frequency curves, and suggestions for executive and financial curves.

At the end of the book are given a checking list and a set of rules for graphic presentation, the two forming practically a summary of the entire contents. The list is a set of questions with which a curve can be checked to see whether it comes up to the standard. The rules are suggested as a basis for the standardizing of graphical presentations. The chapters are logically arranged, but the headings given under the chapter numbers in the list of contents could well have been repeated in the text, thus definitely locating the particular heading.

The book will prove a useful aid to the many who hitherto, in preparing charts and curves, have depended mainly on their own ingenuity to satisfy the needs of executives as to the information in and the arrangement of the graphical reports rendered.

POWER

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Candid Chats

Don't Be a Nagger

> **Results are what count, and as long as an engineer gets them quickly and efficiently, how he gets them is his own concern.**
>
> * * * * * * * * * * *
>
> **Nothing on earth demoralizes an organization and takes the heart out of an engineer like a manager who is constantly changing his mind.**

IF A MAN IS HIRED to fill a certain position, give him credit for having horse sense enough to run his own job, at least until he proves the contrary to be true.

By this is not meant that a manager is never to check up the work that his engineer is doing, but *results are what count, and as long as an engineer gets them quickly and efficiently, how he gets them is his own concern.*

No two humans were ever created exactly alike. Such being the case, it is seldom that any two will tackle a given proposition in the same way—and right there is the rub.

Give a man credit for a personality and ideas of his own, and don't tell him he is blundering the instant he deviates from a plan you had in mind. Forget the details. The chances are ten to one he knows more about them than you do, and anyway, your engineer is being paid for the express purpose of looking after them and relieving your shoulders of that burden.

Don't make an errand boy of him, or reduce him to such a state of indecision that he will come and ask if it will be all right to have a couple of men out Sunday to wash the boilers. Such tactics kill all the initiative an engineer possesses.

When you give instructions make them clear and concise and give them to the chief and not to some man under him, if you wish him to maintain any discipline and have the respect of his helpers; and before you give instructions settle in your own mind first, just what result you wish to attain and then stick to it.

Nothing on earth demoralizes an organization and takes the heart out of an engineer like a manager who is constantly changing his mind.

A man gets so he will exert no effort whatever to "make things hum," because he knows that as soon as he gets a piece of work nicely started, in will come the boss, change his mind and then a "patched up," "made over" job will be the result.

In other words, be consistent. Treat your chief engineer as if he were a man who knows his business, and don't nag him until his head is so busy thinking up new words to describe your special brand of ivory that he has no time to think of his plant, as the former kind of "thinks" don't help the coal pile.

[Contributed by Karl A. May, Kearsarge, Mich.

Addition to the Westport Power Plant

By Warren O. Rogers

SYNOPSIS—Owing to increased business the Westport power plant, the original capacity of which was 22,500 kw., has recently been enlarged by putting in a 15,000-kw. turbine and six water-tube boilers, each with a heating surface of 10,470 sq.ft. The boiler furnaces are each equipped with an 11-retort underfeed stoker. A special design of jet condenser, so far as known, the largest built, is used with the new turbine, and is designed to take care of 200,000 lb. of steam per hour with a vacuum of 28.5 inches. The brick chimney is supported by steel girders and columns. The base of the chimney is level with the top of the boiler-room roof, 65 ft. above the ground level.

The electric and gas business in Baltimore, Md., is controlled by the Consolidated Gas, Electric Light & Power Co., and until three years ago nearly all of the electrical energy was generated at the company's steam plant at Westport, on the west bank of the Middle Branch of the Patapsco River. Prior to the addition the plant had a rated capacity of 30,000 hp.; a small steam plant of 8000-hp. capacity on Gould St. and a small water-power plant at Ilchester are also operated by the company.

Although the Westport plant, Fig. 1, is tied in with the McCalls Ferry* hydro-electric plant of the Pennsylvania Water & Power Co., this company is separate and distinct

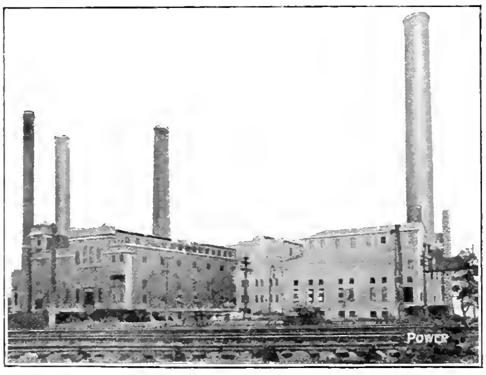


Fig. 1. Showing Addition to Westport Power House

as an organization, from the Consolidated Gas, Electric Light & Power Co. The former company, however, has a contract with the latter calling for the capacity of the latter's plant in case of failure to the hydro-electric station apparatus or transmission lines. This arrangement also applies to the United Railways Co., which has a steam plant of 26,000-hp. rating that is operated in an auxiliary capacity during the peak-load hours.

Since the contract was made with the Pennsylvania company the electric business of the Consolidated company has increased 150 per cent., being now 2½ times as great as three years ago. As a matter of prudence the Westport plant has been enlarged sufficiently to take care of its business in case of a breakdown of the water-power plant. The former equipment consisted of four 2500-kw., one 5000-kw. reciprocating units, as shown in

Fig. 2. View of the Old Engine Room, Westport Power House

Fig. 2, and a 7500-kw. turbine, or a total continuous capacity of 22,500 kw. The new 15,000-kw. turbine thus gives a station capacity of 37,500 kw. The old plant has a total in boiler heating surface of 120,000 square feet.

Turbine Room

The turbine room, which contains two horizontal turbines, adjoins the engine room shown in Fig. 2. The smaller turbine is a 7500-kw., 13,200-volt, three-phase, 25-cycle unit running at 1500 r.p.m. It occupies the space formerly taken up by a vertical turbine, recently discarded. The condensing apparatus of the original turbine is used with the newer unit and consists of two jet condensers, two 13x14-in. engine-driven 20-in. volute pumps for injection water, and two 8&10x24x24-in. dry-vacuum pumps, the steam ends of which are equipped with Corliss valve-gear. One of the condensers is shown in Fig. 3.

The 15,000-Kw. Unit and Condenser

The new 15,000-kw. unit is shown in the foreground of Fig. 4. It is a 13,200-volt, three-phase, 25-cycle, 1500-r.p.m. machine. The condenser for this unit is, as far as

*Described in the May 13, 1913, issue of "Power."

known, the largest jet condenser ever built. A partial view of one end is shown in Fig. 5 and a side view in Fig. 6. It is designed to take care of 200,000 lb. of steam per hour, at an absolute pressure of 1.5 in. with 70 deg. F. injection water, using 25,000 gal. per minute.

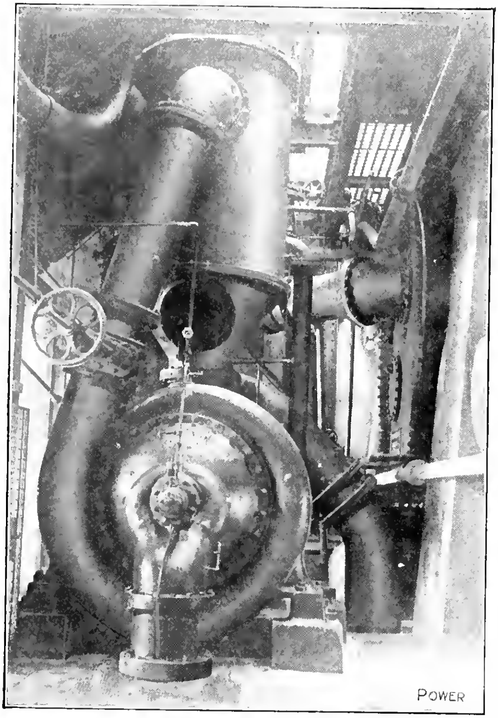


FIG. 3. ONE OF THE CONDENSERS USED WITH THE 7500-KW. TURBINE

The floor space available for the condenser and air pumps under the turbine and between the turbine foundation walls was 11x15 ft. This necessitated several departures from the usual design of jet condensers and demanded highly efficient apparatus.

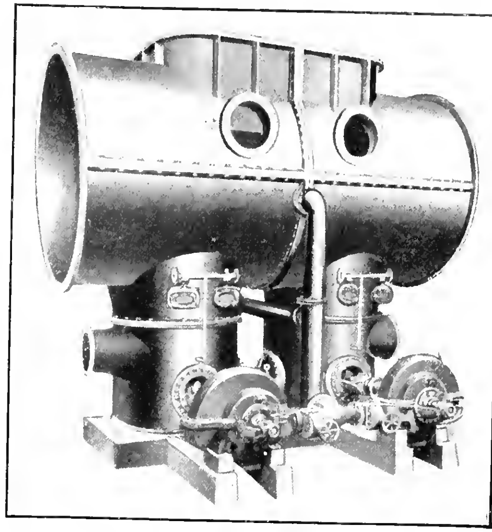


FIG. 6. LARGEST KNOWN JET CONDENSER, CAPACITY 200,000 LB. OF STEAM PER HOUR

The condenser consists of a horizontal cylinder 10 ft. in diameter and 20 ft. long, with a 7-ft. 6-in. by 10-ft. 9-in. rectangular flanged exhaust opening at the top and two 6-ft. diameter wells on 8-ft. centers at the bottom. These wells are bolted to a base plate with the condenser. The pumps are driven by two turbines mounted on independent base plates and are located below the generator and connected through extended shafts with flexible couplings. These turbines at their rated speed of 1050 r.p.m. develop 300 hp. each under full-load conditions.

To effect a balanced condition and uniform distribution, the injection water is taken in at each end of the condenser through two 24-in. pipes running through the condenser shell and bolted to each head. These pipes are fitted with brass nozzles which direct the water against spray plates; the water is further broken up by staggered trays with serrated edges, placed under the injection pipes. The air and noncondensable vapors are removed from the condenser at each side. This arrange-

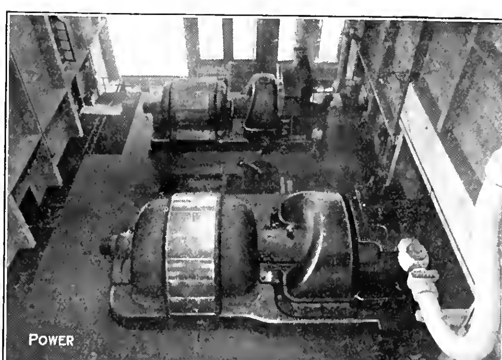


FIG. 4. GENERAL VIEW OF THE TURBINE ROOM FROM THE TRAVELING CRANE

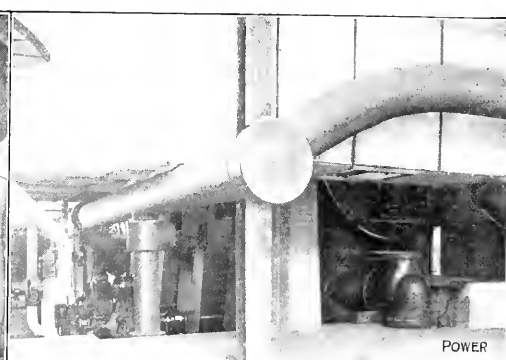


FIG. 5. ONE END OF THE LARGE JET CONDENSER AND THE PUMP TURBINES

Fig. 7. View at Rear of the Boilers

ment of water distribution and spray, combining the features of parallel-flow and counter-current types of jet condensers, makes it possible to effect close terminal differences between the vacuum temperature and the temperature of the discharge water at light and at full loads. Due to the arrangement of the air and removal pumps, it is possible to operate the condenser with but one set of pumps if at any time the turbine is carrying half-load.

Boiler House

The boiler room is laid out at right angles to the turbine room and contains at present six boilers each of 10,470 sq.ft. of heating surface, forming a unit designed to furnish steam for one 15,000-kw. turbo-generator or 1.13 kw. capacity per sq.ft. of boiler heating surface. Additional units of six boilers each will be added for each 15,000-kw. generator installed. The present stack serving the six boilers is of sufficient capacity to serve another unit of six.

Two walls of the boiler house are temporary, being made of asbestos-covered corrugated iron, which can be readily removed for extension. The asbestos color corresponds closely with the color of the concrete in the permanent building walls, and the general appearance of the structure is not marred by the temporary walls.

The boilers are set singly to allow access to both sides of the furnace, and they are supported from the building steel. The aisle between the rear ends of the two rows of boilers is unusually wide, giving ample space for operating blowoff valves and for repair work (Fig. 7). The space in front of the boilers is wide and well lighted, providing ample operating space for stokers, etc. (Fig. 8).

The building is provided with modern sanitary features consisting of a lavatory, toilets and shower baths. Ample light is admitted by numerous and large windows, rolled-steel sash and wire glass being used, with ventilating sections. A large storeroom is provided for in the basement, for repair materials and supplies.

Boilers and Stokers

The water-tube boilers are three-pass, of the water-leg type, and are designed to operate at 200 lb. pressure. Each boiler is provided with a superheater of 1425 sq.ft. of heating surface, to give 100 deg. of superheat under all conditions of load. The ratio of superheater surface to the boiler heating surface is 1 to 7.34 sq.ft.

A balanced draft is maintained in the combustion chamber by means of apparatus which controls the flue damper of the boilers and also the forced-draft damper of the stoker, so that a constant draft or negative pressure is maintained. Each boiler has four blowoff valves and an 8-in. steam delivery pipe.

Each boiler is equipped with an 11-retort underfeed mechanical stoker with a grate area of 156 sq.ft., this being the area of the combustion chamber in a horizontal plane. This gives 67 sq.ft. of boiler heating surface to 1 sq.ft. of grate area. These stokers are guaranteed to maintain twice the boiler rating continuously or three times the boiler rating for a period of two hours. Forced draft is provided by four paddle-wheel blowers directly connected to horizontal engines; they deliver air at a maximum pressure equivalent to 6 in. of water.

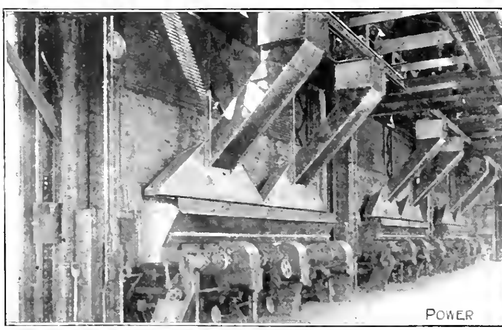


Fig. 8. Stoker Side of the Boilers

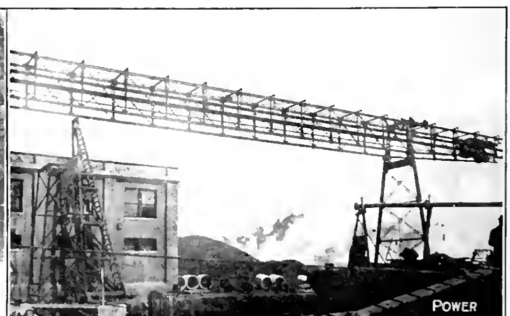


Fig. 9. Trolley Bridge and Grab Bucket

The stack has an internal diameter of 20 ft. 3 in. and is built of radial brick. It is supported on six heavy steel columns and 72-in. girders, the base of the stack being 65 ft. above the foundation on which the steel is carried. The height of the stack is 215 ft. above the steel supports and 250 ft. above the boiler grates. The foundation for the stack is a monolith 35x10, 8 ft. deep, resting on 198 piles driven to an average depth of 25 ft. Grillages of steel beams are placed in this foundation, distributing the weight evenly from the columns to all of the piles. The weight of the stack is 1224 tons. The cross-section is 320 sq.ft. or 2.92 sq.ft. of grate area to 1 sq.ft. of stack area. When the additional six boilers are installed there will be 5.8 sq.ft. of grate area to 1 sq.ft. of stack area.

The steel breechings connect the flues at the tops of the boilers and extend in a straight line to the bottom of the stack, which they enter by making a quarter turn upward. The dimensions of the breeching are gradually increased by a tapering construction to give proper cross-section for the several boilers connected. The arrangement at the base of the stack gives minimum friction or interference of gases in entering.

The new boiler house is designed to receive coal by cable cars over a bridge from a high-speed coaling tower to be constructed on the bulkhead line. At present coal is transferred from the system supplying the boiler house serving the reciprocating engines.

The coal is brought to the plant in barges, from which it is lifted by a grab bucket and transferred by a trolley over a bridge into the old house (Fig. 9). Coal is deposited in a movable crusher which, after crushing, delivers it to the bunkers. From one of these bunkers it flows by gravity into a 2-ton skip hoist which lifts it to a hopper above the roof, from which it is discharged to a 3-ton electrically operated car. This car transfers coal over a bridge on the roof of the power house to the new boiler house and dumps it into hoppers. From these hoppers it is delivered into hand-push cars which distribute it to the bunkers above the new boilers. The bunker above three of the boilers has a capacity of 400 tons and that above the other three has a capacity of 600 tons to provide for an additional row of boilers to be installed in the future.

From these bunkers the coal passes to automatic weighing scales, two for each boiler. Each scale discharges into

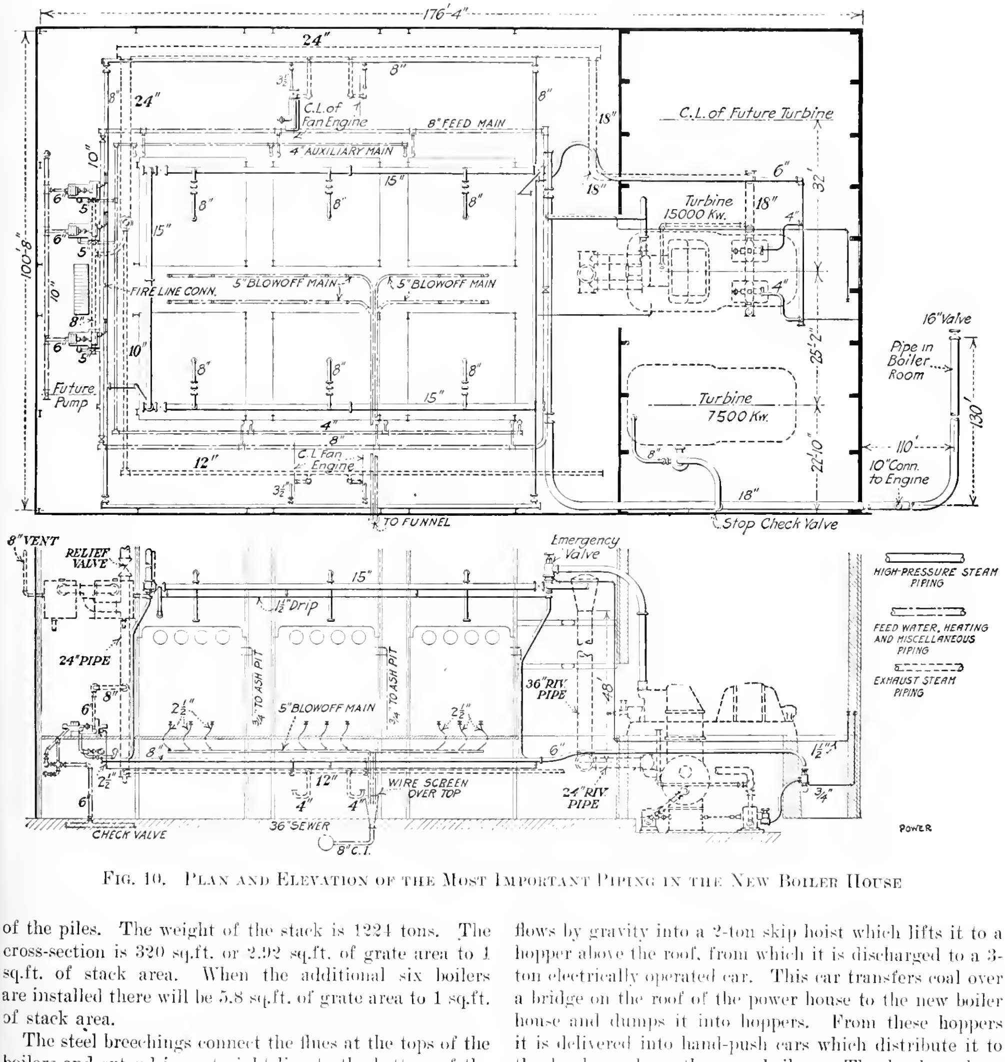


FIG. 10. PLAN AND ELEVATION OF THE MOST IMPORTANT PIPING IN THE NEW BOILER HOUSE

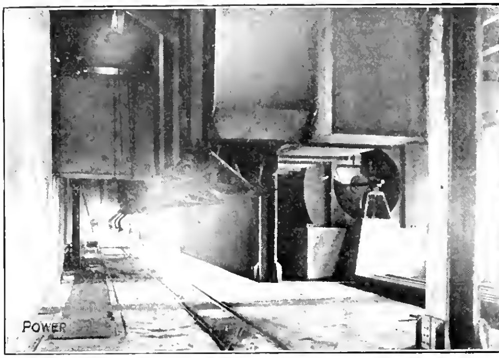


Fig. 11. Ash Outlets from Ash Pits

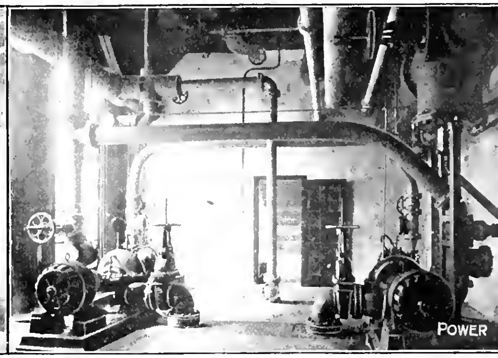


Fig. 12. Service and Heater Pumps

a chute equipped with a distributor which feeds the stoker hoppers, shown in Fig. 8.

Ashes from the stokers drop into ash hoppers in the basement. At the bottoms of these hoppers are 24x36-in. cast-iron gates. Ash cars run on tracks below these hoppers (Fig. 11) and are loaded by opening the gates mentioned. The ashes are used to reclaim land adjacent to the boiler house.

Piping

Fig. 10 gives a plan and section of the more important piping in the new boiler house and turbine room. The main high-pressure piping in the boiler house consists of a loop of 15-in. pipe. Each of the boilers connects with this header through a long 8-in. bend. The 15,000-kw. turbine is served by a 14-in. connection. The new boiler house is connected with the old one by an 18-in. pipe line and the 7000-kw. turbine is supplied from this pipe, the arrangement of valves being such that steam can be taken from either the old or the new house.

The high-pressure steam for auxiliaries in the basement of the turbine and boiler rooms is supplied by another loop header located in the basement. This header receives steam from the main boiler-room header through either of two 8-in. connections and supplies the four blower engines in the basement, the steam-driven pumps and turbine auxiliaries.

Van Stone joints and welded nozzles were used on all high-pressure piping. Steel valves with monel-metal seats were used and 1914 drilling for all flanges. Remote-control valves are installed on the principal units and main connections so that some may be closed from a control point in emergency.

The exhaust piping is located in the basement, the connections from each of the auxiliaries leading to a main 24-in. exhaust line which rises to the two feed-water heaters. Just above the connection to the feed-water heaters a 24-in. relief valve is placed to force the steam through the heaters and to relieve the exhaust above a predetermined pressure.

All steam piping is covered with 85 per cent. magnesia of ample thickness to conserve heat, and the various classes are painted with colors that indicate their functions. The high-pressure steam piping is white, exhaust steam buff, fresh cold water blue, salt water green, and blowoff and drain connections black.

Two 10,000-hp. open heaters receive the exhaust steam and deliver the hot water to a V-notch recording meter and tank. An 8-in. vent with exhaust head is provided for each of the heaters, to pass air and excess steam.

All of the pumps for the new boiler house are located in the space under the stack on both the basement and the boiler-room floor levels, this location being central for present and future boilers.

Three boiler-feed pumps (Fig. 13) are provided, each of 500-gal. capacity per min. against 240 lb. per sq.in. They are driven by 110-hp. noncondensing, three-stage turbines at 2500 r.p.m., the pump having an efficiency of 65 per cent.

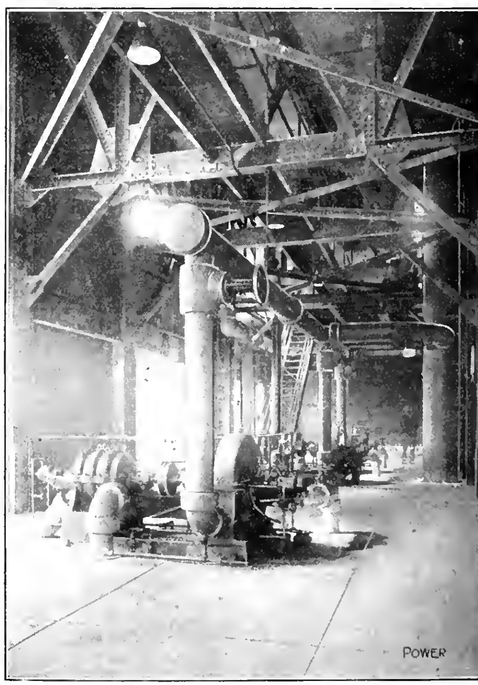


Fig. 13. Boiler-Feed Pumps

PRINCIPAL EQUIPMENT OF THE NEW EXTENSION TO THE WESTPORT POWER PLANT

No. Equipment	Kind	Size	Use	Operating Conditions	Maker
1 Turbine	Horizontal Curtis	7500-kw.	Main unit	175 lb. steam, 100 deg. sup., 1500 r.p.m.	General Electric Co.
1 Turbine	Horizontal Curtis	15,000-kw	Main unit	175 lb. steam, 100 deg. sup., 1500 r.p.m.	General Electric Co.
2 Condensers	Jet	72,000 lb. steam per hr	With 7500-kw. turbine	28½-in. vacuum	Alberger Pump & Condenser Co.
2 Engines	Fleming	12x14-in	Driving circ. pumps	250 r.p.m	Harrisburg Foundry & Machine Works
2 Pumps	Volute discharge	20-in	With small condensers	Engine-driven	Alberger Pump & Condenser Co
1 Condenser	Jet	25,000 gal. per min	With 15,000-kw. turbine	28.5-in. vacuum	C. H. Wheeler Mfg. Co.
2 Turbines	Single-stage	300-hp.	Driving condenser pumps	1050 r.p.m	Terry Steam Turbine Co.
2 Pumps	Thissen	No. 20	With large jet condenser	1050 r.p.m	C. H. Wheeler Mfg. Co.
6 Boilers	Edge Moor	10,470 sq. ft. heating surface	Steam generators.	200 lb. steam, 100 deg. superheat	Edge Moor Iron Co.
6 Superheaters	Foster		With boilers	100 deg. superheat	Power Specialty Co.
6 Stokers	Taylor	8 ft., 3½ in. x 19 ft., 6 in.	Boiler furnaces	Automatic	American Engineering Co.
6 Meters	Steam-flow		On main boilers	Continuous	General Electric Co.
12 Scales	Automatic		Weighing hopper coal	Intermittent	Richardson Scale Co
1 Crane	Gantry	7500-lb. capacity	Unloading coal	Motor-operated	Morgan Eng. Co
4 Engines	Fleming	9½x12-in	Driving Sirocco fans	Variable-speed	Harrisburg Foundry & Machine Works
4 Fans	Sirocco	9 ft. dia. wheels, 3 ft., 3½ in. wide	Forced draft	Engine-driven, variable-speed	American Blower Co.
6 Regulators	Draft-control		Air control to furnaces	Maintaining balanced draft	Blaisdell-Canady Co.
2 Pumps	Volute	2½-in	Service	Motor-driven, 1420 r.p.m	Alberger Pump & Condenser Co
2 Motors	Induction	7½-hp	Driving service pumps	440 volts, three-phase, 1420 r.p.m.	Westinghouse Electric & Mfg. Co.
2 Motors	Induction	20-hp	Driving heater pumps.	440 volts, three-phase, 1430 r.p.m.	Westinghouse Electric & Mfg. Co
2 Pumps	Volute	8-in	Supplying heaters	28-lb. head, 1430 r.p.m	Alberger Pump & Condenser Co
2 Heaters	Cochrane	300,000-gal. cap.	Feed water	Exhaust steam from aux. turbines	Harrison Safety Boiler Works
1 Meter	V-notch		Measuring feed water	Continuous	Harrison Safety Boiler Works
3 Pumps	Turbine	5-in	Boiler feed	2400 r.p.m., turbine-driven	Alberger Pump & Condenser Co
3 Turbines	Three-stage		Driving boiler-feed pumps	2400 r.p.m., 185-lb. steam	Alberger Pump & Condenser Co.
2 Pumps	Recip. 2-stage	24x24-in	Dry vac. for 7500-kw. turbine	Engine-driven	Alberger Pump & Condenser Co
2 Engines	Corliss, horizontal	8x24-in	For dry vac. pumps	Variable-speed	Alberger Puoip & Condenser Co
2 Pumps	Injection volute	16-in.	7500 turbine condensers	Engine-driven	Alberger Pump & Condenser Co

Two service pumps, each 150-gal. capacity per min. against a 90-ft. head, are driven by 7½-hp. induction motors at 1440 r.p.m. The efficiency of these pumps is 55 per cent.

These pumps supply water to two 25,000-gal. service tanks on the roof of the boiler house, one located on each side of the stack and supported by the same steel structure that carries the stack. This water is used for cooling and miscellaneous purposes.

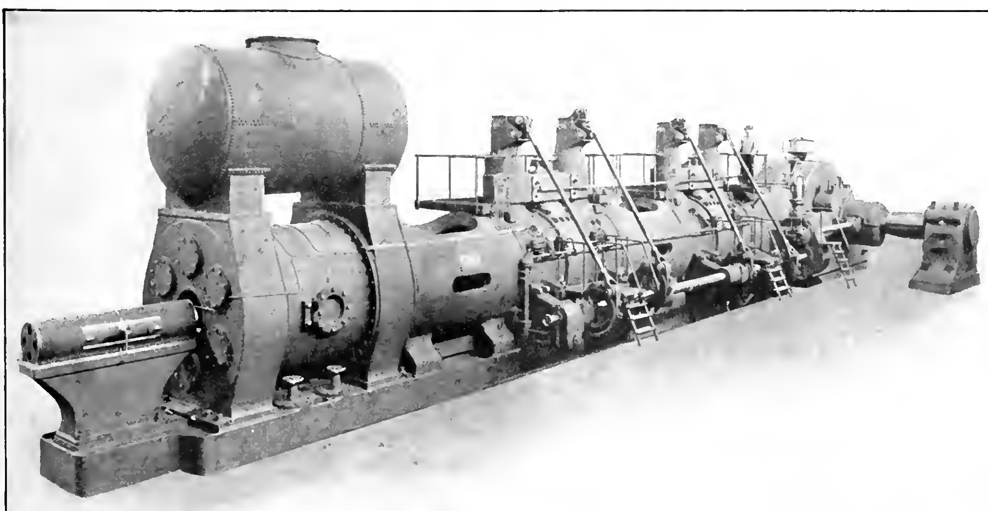
Two heater pumps, each of 1000-gal. per min. capacity against a 50-ft. head, are driven by 20-hp. induction motors. Each pump has an efficiency of 65 per cent.

Condensing water is supplied through a reinforced-concrete tunnel 10x12 ft. inside dimensions and the discharge water is carried away by another tunnel of the same construction and dimensions, under the basement floor, but located at a somewhat higher elevation. From the boiler room to the bulkhead line, a distance of 267 ft., the water is carried through two lines of reinforced-concrete pipe, 9 ft. inside diameter with a 9-in. wall. These pipes were molded in sections 15 ft. long, each section weighing 28 tons.

Large Blowing Engine

The photograph shows the largest single-tandem, gas blowing engine constructed to date in this country. It is one of two units built by the Mesta Machine Co. for the Pennsylvania Steel Co.'s plant at Steelton, Penn., and has gas cylinders 46 in. in diameter, air cylinders 84 in., and a stroke of 60 in. The speed will range from 45 to 85 r.p.m., depending upon the operating conditions.

The air end is equipped with automatic plate valves (Iversen patent) that require no valve-gear, which makes possible the placing of the air cylinder directly back of the gas cylinders, so that the air-cylinder piston can be driven directly through an extension of the gas-cylinder piston rod. The engine is of the center-crank type.



Largest Single-Tandem Blowing Engine

Recent Development in the Construction of the Uniflow Engine

By Prof. J. Stumpf*

Since the first uniflow engine was erected in the shop of the Erste Bruenner Maschinenfabrik, engines aggregating more than 600,000 hp. have been put in operation. This figure proves better than words can do the value of the uniflow principle and the success is the more gratifying to the pioneer, because in the beginning he had to back the new idea against almost everybody.

Much credit must be given to the German licensees such as Gebruder Sulzer, Maschinenfabrik Augsburg-Nuernberg, Elsaessische Maschinenfabrik, Ehrhardt & Sehmer, Maschinenfabrik Esslingen, A. G. der Goerlitzer Maschinenfabrik and Maschinenfabrik Badenia, which last developed the uniflow locomobile engine. Professor Stumpf praises especially Sulzer Brothers, whose uniflow engines show the same high-grade design and workmanship as everything manufactured by this company. The largest engine which they have built is one of 2000 hp. installed in a cotton mill. Still larger engines have been made by Ehrhardt & Sehmer for driving rolling mills, among which are a 6000 and a 7000 hp., probably the largest output for single-cylinder engines ever made.

The standard Sulzer engines have no tail rod. It required much experimental work to find the mixture of cast iron suitable for piston and cylinder, and a large self-supporting piston needs careful lubrication to insure reliable operation. Other builders, like Ehrhardt & Sehmer, use tail rods with their big engines. Taking up the weight of the piston on a bearing surface outside of the cylinder facilitates lubrication, the bearing surface being small and having low temperature; the friction in the cylinder is reduced to that of the piston rings only, insuring long life of this part of the engine. Cylinders for big uniflow engines have to be bored in such a way as to make the bore uniform under working temperatures.

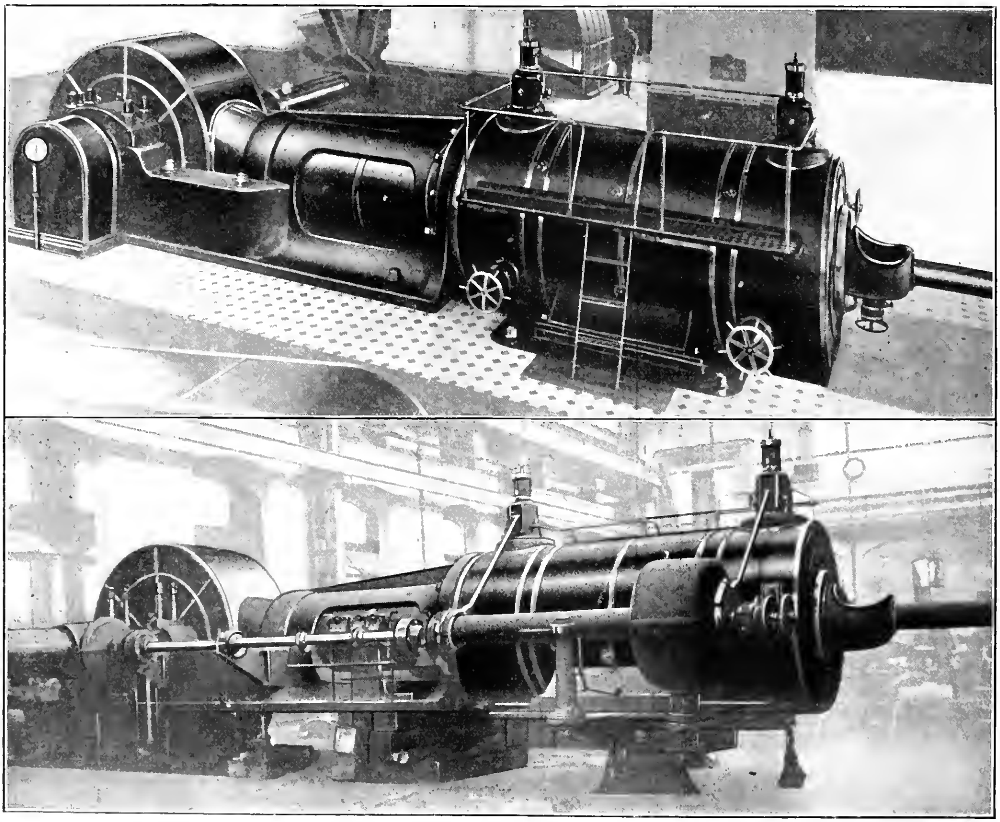


Fig. 1. Two Views of 2000-Hp. Sulzer Uniflow Engine for a Cotton Mill

In Fig. 1 are given two views of the 2000-hp. Sulzer

*Abstract by W. Turnwald of an article by Prof. Stumpf published in the "Zeitschrift d. Vereines deutscher Ingenieure."

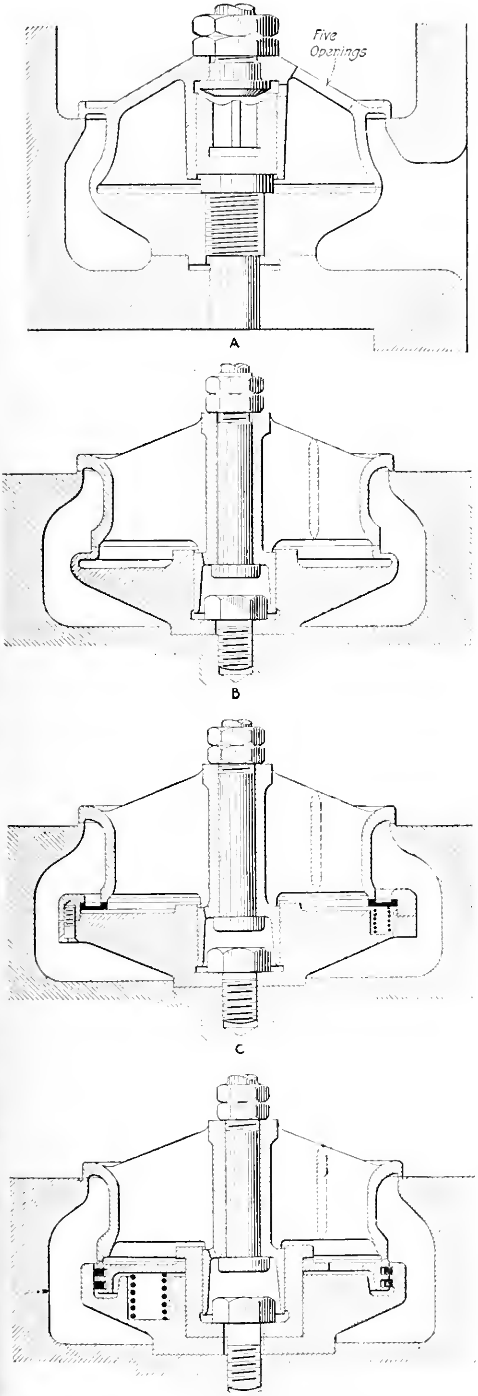


Fig. 2. Poppet Valves with Flexible Seats

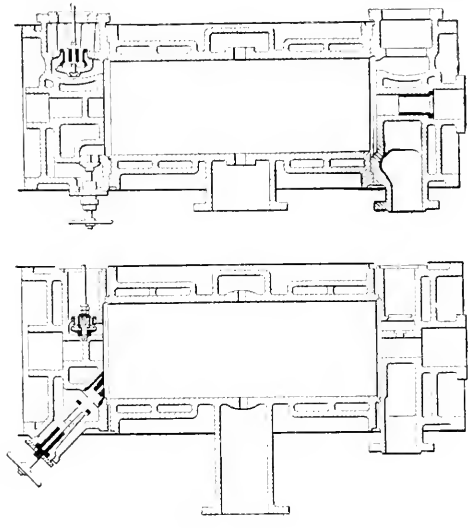


FIG. 3

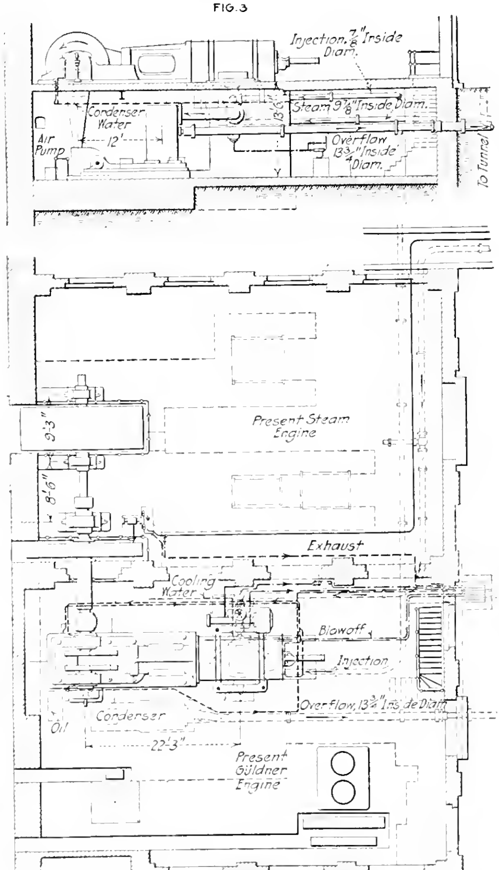


Fig. 1. Plan and Elevation of 2000-Hp. Installation

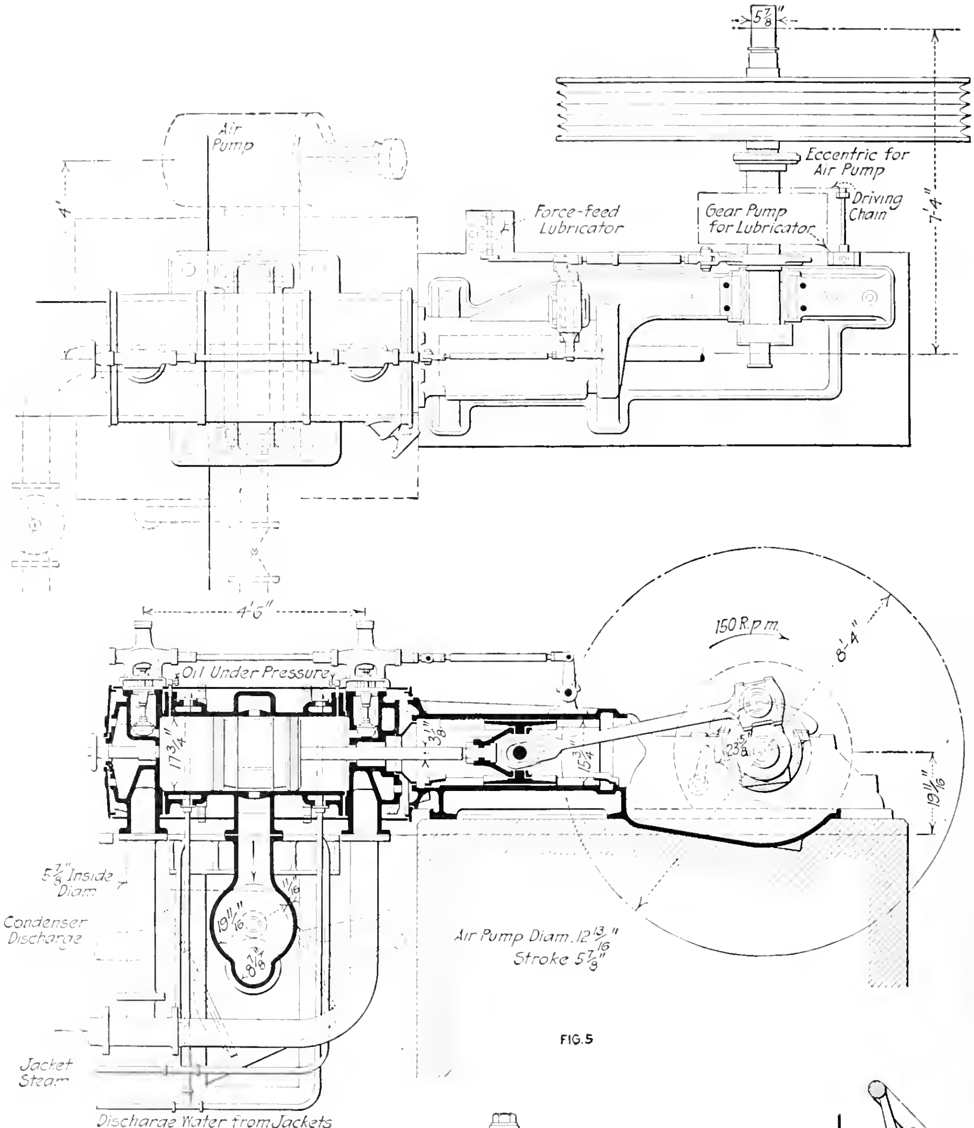


FIG. 5

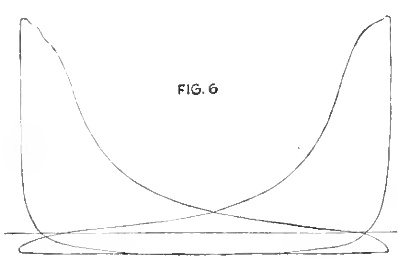


FIG. 6

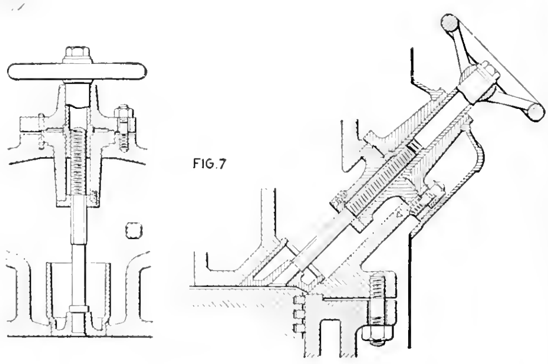


FIG. 7

engine; this engine having a tail rod only because the order called for it.

The driving parts, even those for driving the condenser air pump, are entirely inclosed. Forced-feed lubrication is used, the oil being supplied under a pressure of about 15 lb. by a small gear pump on the layshaft. The pump draws the oil from a reservoir in the basement and forces it into the main bearings, the discharge from the oil is collected in the crank pit and runs through a filter back to the reservoir to be used over and over again. Cylinder, stuffing-box and valve stems are lubricated from a separate oil pump, which is also driven by the layshaft; every feeder has its own plunger and the quantity of oil pumped is easily adjustable. The cylinder-oil consumption of a single-cylinder uniflow engine is of course considerably less than that of two- or three-cylinder compound engines.

All the larger engines are now built with layshaft and layshaft governor. The Sulzer engines have the governor close to the head-end bearing to prevent unnecessary deflection of the shaft. The governor acts by changing the stroke and the angle of advance of the eccentrics. Valve motions for uniflow engines have to be adjusted with small lead, and since the range of cutoff is short—only 25 per cent. maximum cutoff being required—it is possible to keep the variation of the lead within one-half of one per cent. or less.

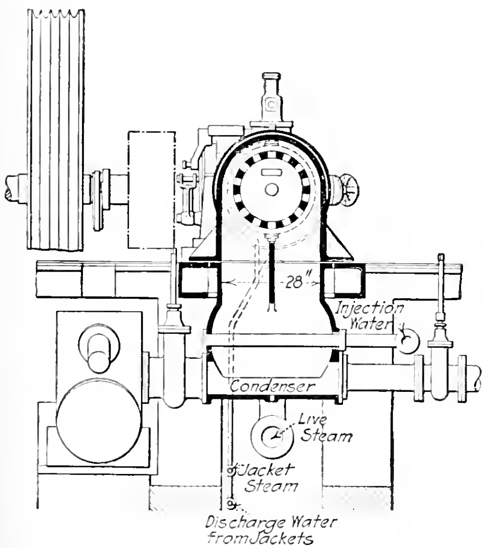


Fig. 8.

Double-beat poppet valves of the type used in compound engines have not proven successful with uniflow engines, where steam tightness of the valves is imperative. This can be insured only by making the valves as short as possible, by making one seat resilient and by balancing only to a certain amount, which has to be calculated. Fig. 2 shows valves of different types, suitable for uniflow engines. Such valves can be comparatively small. The cutoff is short and the gain in economy by reducing the clearance space outweighs the loss due to throttling. A good example of this is the cylinder of a pumping engine shown in Fig. 3, in which the clearance was reduced from 4 to 1.3 per cent. by using smaller valves, resulting in a reduction in steam consumption of more than one pound per horsepower-hour.

The elevation and plan of the 2000-hp. Sulzer engine as installed are shown in Fig. 4. All the piping is beneath the floor level, the steam pipe at one side of the engine, the exhaust pipe and air pump at the other. The condenser is connected to the exhaust belt through a wide opening so the pressure can equalize immediately.

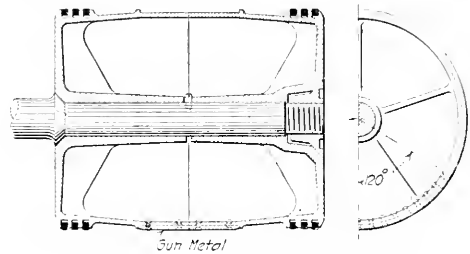


Fig. 9. Piston of Uniflow Engine

The air pump is driven from the main shaft by means of a crank and bell crank.

Belts are used for transmission, one for every story of the factory. The governing of the engine fulfills all the requirements of spinning machinery, with a comparatively light flywheel, because the governor of a uniflow engine controls more directly than in the compound engine where the influence of the governor is limited to the high-pressure cylinder. The steam consumption of this engine is better than that of a triple-expansion of the same size. Indicator diagrams are shown in Fig. 6; noteworthy is the shape of the compression line, which is almost adiabatic.

An 18x24-in., 150-r.p.m. side-crank engine, designed some time ago, is shown in Figs. 5 and 8. Cylinder and cylinder heads are jacketed, the steam for the cylinder jackets being taken from the steam main before the stop valve so the engine may be warmed up before starting it.

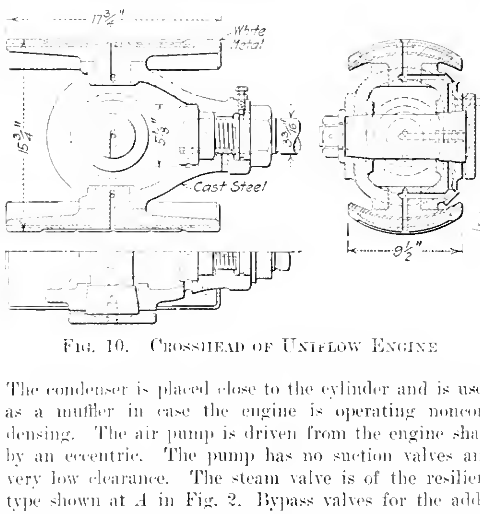


Fig. 10. Crosshead of Uniflow Engine

The condenser is placed close to the cylinder and is used as a muffler in case the engine is operating noncondensing. The air pump is driven from the engine shaft by an eccentric. The pump has no suction valves and very low clearance. The steam valve is of the resilient type shown at A in Fig. 2. Bypass valves for the additional clearance space, Fig. 7, are of a new type to give the smallest clearance when operating condensing. For relief valves the steam valves are relied on. The clearance space of this engine does not exceed 1.25 per cent. when operating condensing. The piston, Fig. 9, which is extremely light, is made in two parts of cast steel, fitted with three rings at each end. No tail rod is used, but the piston has a brass-mounted bearing surface in the middle and covering one-third of the circumference. The piston itself has ample clearance all around. The details of the crosshead are shown in Fig. 10.

It is wrong in principle to build uniflow engines for condensing service with auxiliary exhaust valves. The short compression is wrong and just as wrong is the increase of clearance space and surface connected with these valves. Even for noncondensing service, with steam pressures as used in modern power plants, auxiliary exhaust valves show no gain.

Professor Naegel, of the Technische Hochschule, Dresden, who conducted elaborate temperature measurements on a uniflow cylinder, says in his report: ". . . . The uniflow engine of the Stumpf type is able to utilize the steam in single-stage expansion in a more perfect way than it was possible to do before with the best multiple-expansion engines. The reason for this is the elimination of the initial condensation and the reduction of heat transmission through the walls, accomplished by the particular flow of steam through head jacket, steam valve, cylinder and exhaust ports, which constitutes the "Unaflow Principle."

Bayer Feed-Water Purifier

The effect of scale on the operating efficiency of a boiler and the difficulty and cost of its removal are factors which have led to the design of various types of apparatus for removing the suspended matter and scale-forming ingredients before the water enters the boiler. It will be generally conceded that this is the proper method to follow and that the solution of the problem rests in securing a device that will do the work efficiently and at a low cost. Quite recently, the Bayer Steam Soot Blower Co., of St. Louis, has given some attention to this question and is putting on the market the purifier illustrated herewith. It is licensed under Ray patents and is made for return-tubular and the various types of water-tube boilers.

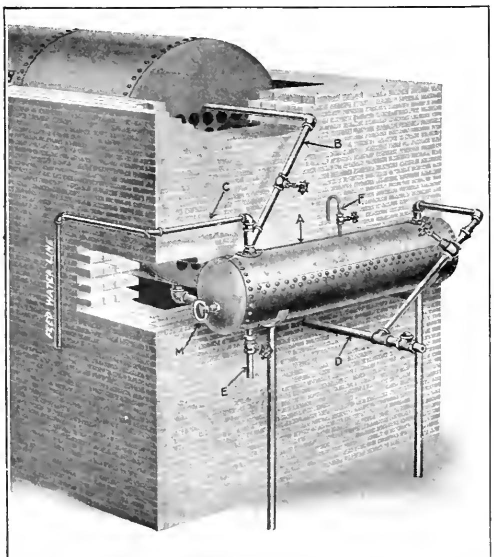


Fig. 1. Bayer Purifier Attached to Return-Tubular Boiler

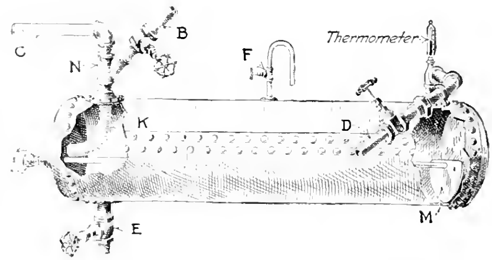


Fig. 2. Separating Tank in Part Section

Fig. 1 shows the purifier applied to a return-tubular boiler and Fig. 2 shows the tank in part section. The device consists of a cylindrical tank varying in size from 16x60 in. for a 100-hp. boiler to 33x144 in., the larger boilers being of the water-tube type. When the boiler is in operation a circulation of hot water is set up through the connecting piping and the tank. Any sludge remains in the tank and may be blown out through pipe *E*, while

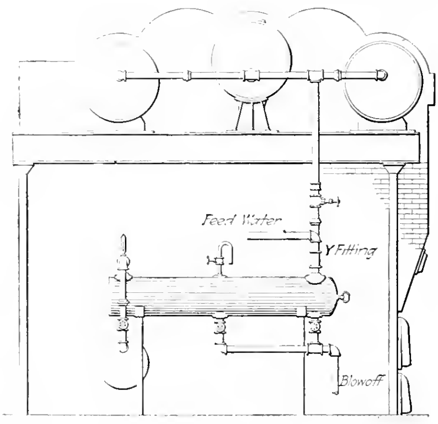


Fig. 3. Stirling Boiler Served by Purifier

the water is forced through an outlet at the top of the tank and returned to the boiler through the blowoff pipe *D*. There are three forces which tend to produce circulation through the system. The internal circulation in the boiler forces the water to the rear end, and it is at this point that pipe *B* enters the boiler just below the water level. The difference in weight of the water columns within and exterior to the boiler also tends to produce circulation, and this is augmented by the action of the ejector nozzle *N* and pressure from the boiler-feed pump. Water thus comes from the boiler at a temperature corresponding to the pressure, mixes with the feed at the Y fitting N and discharges against the head of the tank through the elbow K to obtain a uniform flow through the tank. The latter is made large enough so that the velocity of the water will be relatively slow, giving time for the foreign matter heavier than water to be deposited on the bottom of the tank. The purified water then returns through pipe D to the boiler. By properly proportioning the sizes of pipes B and C, the water in the tank can be maintained at a temperature but little lower than that in the boiler. The tank will therefore separate the suspended matter and scale-forming ingredients affected by temperature. If it is necessary to treat the water, the reagent should be mixed with the feed water before it enters the tank, so that the impurities will be precipitated in the purifier instead of in the boiler.

Scraper M has been provided to pull the deposited matter toward the blowoff at the opposite end of the tank. Valve F allows air to escape when first filling the tank and may also be used for drawing off samples of water for testing purposes.

On other types of boiler the operation is substantially the same. The pipe discharging to the tank is always tapped to that portion of the boiler just below the water line, toward which the water on the surface flows. The return pipe is connected to the water leg, mud drum or boiler blowoff, depending on the type of boiler. Fig. 3 shows the purifier connected to a Stirling boiler.

Examination Questions

Two sets of examination questions written from memory after the test was over:

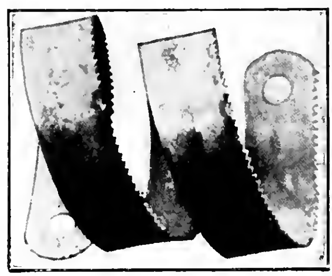
1. How would you determine the highest safe working pressure on a boiler of the horizontal type?
2. How would you determine the area of safety valve—first, lever valve; second, pop valve—required on a horizontal tubular boiler?
3. How could you determine at what pressure a lever valve was set to blow off, also a pop valve?
4. How would you figure out the number of braces required to properly support flat surfaces above the tubes in a boiler of the horizontal type?
5. Give the dimensions for riveted joints single and double, also the sizes of rivets required for the following thicknesses of metal: $\frac{5}{16}$ in.; $\frac{7}{16}$ in.; $\frac{3}{4}$ in. Give pitch of stay-bolts, also size for bracing the following area: 20x32 three-eighth-inch plate to sustain 120 lb. pressure.
6. Determine the capacity of a pump or injector necessary to supply a boiler rated at 100 hp. with sufficient water, the calculation to be based on the assumption that 30 lb. of water is evaporated per horsepower per hour.
7. Give your ideas for the proper connections of water column and steam gage to boilers. Make a sketch of same.
8. What is the best way to set two 60-in. boilers? Give thickness of walls, spaces and such dimensions as are necessary for the execution of the work. Describe the principle of fuel combustion, the effects of sulphur in fuel, the necessary elements and conditions for best results.
9. Describe what you would do in making an internal examination of a horizontal tubular boiler.
10. Describe what you would do in making an external examination of a boiler.
11. Give the names of the different types of boilers you are familiar with and how classified.
12. Give the names of the principal types of boilers in common use.
13. State what experience you have had in boiler construction, repairing or operation.
14. What in your opinion is the cause of leaky tubes?
15. How would you determine the point of leakage from an internal view of boiler, and how would you determine if inside plate was cracked or rivet broken from viewing the external part of boiler where the leakage was?
16. What, in your opinion, is the cause of boiler explosions?
17. What means would you suggest to minimize the hazard?

1. Draw a diagram showing the admission valves of a Corliss leaking and one of the exhaust valves leaking.
2. What is the effect on a cross-compound if the valves of the high-pressure sides are leaking?
3. If the receiver pressure is too high what effect has it? What would you do to equalize the work done in both engines?
4. How would you change the speed of the Corliss engine?
5. Draw a diagram of a high-speed engine, showing the valve leaking.
6. Which would you prefer—a simple slide-valve engine or an automatic cutoff, both having the same-sized cylinders and to run at the same speed doing the same work, and why? Is there any difference in horsepower?
7. Where is the steam cut off in a pump and can the valve motion be made to cut off in an ordinary steam pump any earlier in the stroke.
8. On a triple-expansion engine draw a diagram showing the intermediate admission valves and exhaust valve leaking.
9. What effect will it have on the low-pressure cylinder, if the admission valves are leaking?
10. In a Corliss engine, what determines the point of cutoff and how?
11. In an automatic cutoff engine what determines the point of cutoff and how?
12. If you want to change a Corliss engine with a single eccentric from noncondensing to condensing, what would you do; and with a double-eccentric engine what would you do?

Nonbreakable Hacksaw Blade

The chief claim for this hacksaw blade, as will readily be appreciated from the illustration, is its flexibility.

The blade shown, twisted into a coil one inch in diameter, was subsequently straightened out and run for the full life of the saw teeth.



NONBREAKABLE HACKSAW BLADES

This type of nonbreakable blade is the latest addition to the line made by E. C. Atkins & Co., Indianapolis, Ind.—*American Machinist.*

A Correction—Hubert E. Collins writes that he was in error in stating in his article on an "Interesting Steam-Pipe Installation," on page 288, issue of Mar. 2, that the main which he describes was covered with 85 per cent. magnesia. The covering used was the Nonpareil High-Pressure type, manufactured by the Armstrong Cork & Insulation Co., Inc.

Some Common Misconceptions—A mass of aluminum weighs one pound; a mass of lead of equal size weighs something more than four pounds. Some will thoughtlessly say that aluminum is more than four times lighter than lead. Weight (heaviness) is an attribute of matter; lightness is absence, or deficiency of weight. To say that one article is a certain number of times lighter than another is like saying of two vessels that one is four times emptier than the other.

It might be added that it is equally erroneous to say that one body or substance is colder than another There is no such thing as cold; there are only varying degrees of heat, although we commonly regard as cold those things that are below 98 deg. F., or below the temperature of the human body. A substance that is at the freezing temperature is quite hot compared with liquid air, as the latter boils violently when placed upon a cake of ice. Temperatures that are fatal to life are far below those used in metallurgical processes.

Properties of Saturated Air

By W. D. Ennis

SYNOPSIS—An explanation is given of underlying principles and method of computing a table of Properties of Air Saturated with Moisture, together with examples of applications of the table.

Most engineers are familiar with the steam table, or table of properties of saturated steam, but not as many of them are as well acquainted with the properties of saturated air. The table presented herewith is the result of computations made by senior students (of the class of 1915) in mechanical engineering at the Polytechnic Institute of Brooklyn: T. B. J. Merkt, Samuel Blakeman, George Wieber, Walter L. Betts, S. Ishimura, R. B. Fuller, Murray Harris, John DeGroot, Harvey Sand, Van Wyck Hewlett.

Before showing some of the uses of the table, the method of computing it will be explained. To begin with, the word "saturated," as applied to a mixture of air and water vapor, has a different meaning from that understood when we speak of "saturated" steam. When dry air and moisture are brought together at any temperature, the moisture vaporizes until the vapor pressure is that "corresponding" with the temperature, i.e., that pressure which, according to the steam table, is the pressure of saturated steam at the given temperature. The mixture is then called saturated air, and the water vapor in the mixture is saturated steam. If, however, the supply of water is insufficient, its pressure, after it is all vaporized, will be less than that which the steam tables give, and the vapor, or steam, will be superheated.

From the Marks and Davis steam tables, at 40 deg. F. the pressure of saturated steam is 0.1217 lb. per sq.in., and its density, or weight per cubic foot, is 0.000410 lb. With these data, we proceed to compute the properties of 1 cu.ft. of saturated air.

According to Dalton's law, in a mixture of two or more gases, the total pressure is the sum of the partial pressures of the constituents, and each partial pressure is that pressure which the gas in question would exert if it alone occupied the total space. If our mixture is 1 cu.ft. at standard atmospheric pressure (14.697 lb. per sq.in.) and 40 deg., the partial pressure of the air is 14.697 — 0.1217 = 14.5753 lb. per sq.in.

The weight of air in the mixture is computed from the formula:

$$W = \frac{144\,P}{R\,(T + 460)} = \frac{2.6986\,P}{T + 460}$$

where

W = Weight of dry air in 1 cu.ft. of mixture, lb.;
P = Partial pressure of air, lb. per sq.in.;
R = 53.36;
T = Temperature Fahrenheit.

The total weight of 1 cu.ft. of the saturated mixture is then

Weight of dry air + weight of steam, or

$$\frac{2.6986 \times 14.5753}{40 + 460} + 0.00041, =$$
$$0.0787 + 0.00041 = 0.07911 \text{ lb.}$$

(Note: 1 cu.ft. of dry air unmixed with moisture, at atmospheric pressure and 40 deg. F., would have weighed $\frac{2.6986 \times 14.697}{40 + 460} = 0.0794$ lb.)

The wetness, or absolute humidity, of the saturated air is defined as

Weight of steam ÷ weight of air, or
0.00041 ÷ 0.0787, = 0.00521.

The table shows that as the temperature increases, the steam pressure and weight of steam increase, while the weight of dry air and its pressure decrease. When a temperature of 212 deg. is reached, the mixture is *all steam*, the air pressure and weight are both zero, and the humidity has the greatest possible value. At all temperatures the mixture weighs less than the same volume of dry air would weigh at standard atmospheric pressure.

Unsaturated air contains less than the maximum proportion of steam for the existing temperature. The steam (consequently superheated) exerts a pressure p' less than the saturated pressure p. Its density, or weight per cubic foot, w' is similarly less than the saturation density w. What is called *relative humidity* is defined as

$$r = \frac{p'}{p} = \frac{w'}{w}$$

Using primes to denote unsaturated conditions,

$$P' = 14.697 - p'; \quad w' = w\frac{p'}{p}; \quad W' = W\frac{P'}{P}$$

and the absolute humidity of the unsaturated air is

$$r' = \frac{w'}{W'}$$

Some Applications

General Gas Equation—One of the commonest formulas in heat and power calculations is that relating to the volume, pressure and temperature of a gas:

$$W = \frac{1}{V} = \frac{144\,P}{R\,(T + 460)}$$

as already stated (V = volume of 1 lb. of gas in cu.ft.). For dry air, R = 53.36, but in nearly all engineering applications we deal not with dry, but with moist air. The value of R for such air is not 53.36, but $\frac{85.8\,w' + 53.36\,W'}{w' + W'}$.

As an illustration, consider a mixture at 200 deg. F., having a relative humidity of 0.90. At this temperature, the saturated steam pressure is p = 11.52. The partial pressure of the superheated steam in this unsaturated mixture is then by definition,

$$p' = r \times p = 0.90 \times 11.52 = 10.368 \textit{ lb. per sq.in.}$$

The weight of 1 cu.ft. of saturated steam at 200 deg. is

$$w = 0.02976 \textit{ lb.}$$

The weight of steam in the unsaturated mixture is

$$w' = rw = 0.90 \times 0.02976 = 0.026784 \textit{ lb.}$$

The partial pressure of dry air in the unsaturated mixture is

$$P' = 14.697 - p' = 14.697 - 10.368 = 4.329 \textit{ lb. per sq.in.}$$

The weight of the dry air is then

$$W' = W\frac{P'}{P} = 0.0130 \times \frac{4.329}{3.177} = 0.0178 \textit{ lb.}$$

Properties of Air Saturated with Moisture

At Normal Atmospheric Pressure P_B = 14.697 lb.

Note: P_B varies about ½ lb. per 1000 ft. of altitude. 7000 grains = 1 lb.

Column T = Temperature Fahrenheit
Column A = Weight of 1 cu.ft. of dry air, lb., = $2.6986 P_B \div (T + 460)$.
Column p = Steam pressure, lb. per sq.in., from steam table. Note: This is the maximum pressure that the steam can exert at the temperature T, so that the steam is saturated.
Column P = Dry air pressure, lb. per sq.in., = $P_B - p$.
Column w = Weight of steam in 1 cu.ft. of mixture (tabular density), lb. This is the maximum weight of steam that 1 cu.ft. of mixture can contain at the temperature T.
Column W = Weight of air in 1 cu.ft. of mixture, lb., = $2.6986 P \div (T + 460)$.
Column $\frac{w}{W}$ = Lb. of steam mixed with 1 lb. of dry air, or absolute humidity.
Column w + W = Weight of 1 cu.ft. of mixture, lb.

T	A	p	P	w	W	$\frac{w}{W}$	w + W
32	0.0807	0.0886	14.608	0.000304	0.0802	0.00379	0.0805
33	0.0805	0.0922	14.605	0.000316	0.0801	0.00394	0.0804
34	0.0804	0.0960	14.601	0.000328	0.0798	0.00411	0.0802
35	0.0802	0.0999	14.597	0.000340	0.0797	0.00427	0.0800
36	0.0800	0.1040	14.593	0.000353	0.0795	0.00444	0.0798
37	0.0799	0.1081	14.589	0.000367	0.0793	0.00463	0.0796
38	0.0797	0.1125	14.585	0.000381	0.0791	0.00480	0.0795
39	0.0795	0.1170	14.580	0.000395	0.0789	0.00501	0.0793
40	0.0794	0.1217	14.575	0.000410	0.0787	0.00521	0.0791
41	0.0792	0.1265	14.570	0.000425	0.0785	0.00550	0.0789
42	0.0791	0.1315	14.566	0.000441	0.0784	0.00563	0.0788
43	0.0789	0.1366	14.560	0.000458	0.0782	0.00586	0.0786
44	0.0788	0.1420	14.555	0.000475	0.0780	0.00609	0.0785
45	0.0786	0.1475	14.550	0.000492	0.0778	0.00632	0.0783
46	0.0784	0.1532	14.544	0.000510	0.0776	0.00657	0.0781
47	0.0783	0.1591	14.538	0.000529	0.0775	0.00683	0.0780
48	0.0781	0.1651	14.532	0.000548	0.0773	0.00709	0.0778
49	0.0780	0.1715	14.522	0.000567	0.0771	0.00736	0.0776
50	0.0778	0.1780	14.519	0.000587	0.0769	0.00763	0.0775
51	0.0777	0.1848	14.512	0.000608	0.0767	0.00793	0.0773
52	0.0775	0.1917	14.505	0.000630	0.0765	0.00823	0.0772
53	0.0774	0.1989	14.498	0.000653	0.0763	0.00855	0.0770
54	0.0772	0.2063	14.491	0.000676	0.0761	0.00888	0.0768
55	0.0771	0.2140	14.483	0.000700	0.0760	0.00922	0.0767
56	0.0769	0.2219	14.475	0.000724	0.0758	0.00956	0.0765
57	0.0768	0.2301	14.467	0.000749	0.0756	0.00991	0.0763
58	0.0766	0.2385	14.459	0.000775	0.0754	0.01028	0.0762
59	0.0764	0.2472	14.450	0.000801	0.0752	0.01064	0.0760
60	0.0763	0.2562	14.441	0.000828	0.0750	0.01104	0.0758
61	0.0762	0.2654	14.432	0.000856	0.0748	0.01114	0.0756
62	0.0760	0.2749	14.422	0.000885	0.0746	0.01186	0.0755
63	0.0759	0.2847	14.412	0.000915	0.0744	0.01221	0.0753
64	0.0757	0.2949	14.402	0.000946	0.0742	0.01274	0.0752
65	0.0756	0.3054	14.392	0.000977	0.0740	0.01320	0.0750
66	0.0755	0.3161	14.381	0.001009	0.0738	0.01380	0.0748
67	0.0753	0.3272	14.370	0.001043	0.0736	0.01416	0.0747
68	0.0752	0.3386	14.358	0.001077	0.0734	0.01467	0.0745
69	0.0750	0.3504	14.347	0.001112	0.0733	0.01518	0.0744
70	0.0749	0.3626	14.334	0.001148	0.0730	0.01572	0.0742
71	0.0748	0.3751	14.322	0.001186	0.0728	0.01626	0.0740
72	0.0746	0.3880	14.309	0.001224	0.0726	0.01685	0.0739
73	0.0745	0.4012	14.296	0.001263	0.0724	0.01744	0.0737
74	0.0743	0.4148	14.282	0.001304	0.0722	0.01805	0.0735
75	0.0742	0.4288	14.286	0.001346	0.0720	0.01869	0.0734
76	0.0741	0.4432	14.254	0.001389	0.0718	0.01934	0.0732
77	0.0739	0.4581	14.239	0.001433	0.0716	0.02061	0.0730
78	0.0738	0.4725	14.224	0.001477	0.0714	0.02069	0.0729
79	0.0736	0.4893	14.2077	0.001523	0.0712	0.02139	0.0727
80	0.0735	0.505	14.192	0.001570	0.0710	0.02222	0.0726
81	0.0734	0.522	14.175	0.001619	0.0708	0.02288	0.0724
82	0.0732	0.539	14.158	0.001670	0.0705	0.02367	0.0722
83	0.0731	0.557	14.140	0.001723	0.0703	0.02447	0.0721
84	0.0730	0.575	14.132	0.001777	0.0701	0.02535	0.0720
85	0.0728	0.594	14.103	0.001832	0.0699	0.02621	0.0717
86	0.0727	0.613	14.084	0.001889	0.0697	0.02712	0.0715
87	0.0726	0.633	14.064	0.001947	0.0694	0.02804	0.0714
88	0.0724	0.654	14.043	0.002007	0.0692	0.02900	0.0712
89	0.0723	0.675	14.022	0.002068	0.0690	0.02998	0.0710
90	0.0722	0.696	14.001	0.002131	0.0688	0.03100	0.0709
91	0.0720	0.718	13.979	0.002195	0.0685	0.03204	0.0707
92	0.0719	0.714	13.956	0.002261	0.0683	0.03312	0.0705
93	0.0718	0.765	13.932	0.002329	0.0680	0.03423	0.0704
94	0.0716	0.789	13.908	0.002398	0.0678	0.03537	0.0702
95	0.0715	0.813	13.884	0.002469	0.0676	0.03655	0.0700
96	0.0714	0.838	13.859	0.002542	0.0673	0.03776	0.0699
97	0.0712	0.864	13.833	0.002617	0.0671	0.03902	0.0697
98	0.0711	0.891	13.806	0.002693	0.0668	0.04030	0.0695
99	0.0710	0.918	13.779	0.002771	0.0666	0.04163	0.0693
100	0.0709	0.946	13.751	0.002851	0.0663	0.04300	0.0692
101	0.0707	0.975	13.722	0.002933	0.0660	0.04440	0.0690
102	0.0706	1.005	13.692	0.003017	0.0658	0.04586	0.0688
103	0.0705	1.035	13.662	0.003104	0.0655	0.04736	0.0686
104	0.0704	1.066	13.631	0.003192	0.0653	0.04891	0.0684
105	0.0702	1.098	13.599	0.003282	0.0650	0.05049	0.0683
106	0.0701	1.131	13.566	0.003374	0.0647	0.0521	0.0681
107	0.0700	1.165	13.532	0.003469	0.0644	0.0538	0.0679
108	0.0699	1.199	13.498	0.003565	0.0642	0.0546	0.0677
109	0.0697	1.235	13.462	0.003664	0.0639	0.0574	0.0675
110	0.0696	1.271	13.426	0.003766	0.0636	0.0592	0.0674
111	0.0695	1.308	13.389	0.003871	0.0634	0.0611	0.0672
112	0.0694	1.346	13.351	0.003978	0.0620	0.0631	0.0670
113	0.0693	1.386	13.311	0.004087	0.0627	0.0652	0.0668
114	0.0691	1.426	13.271	0.004198	0.0624	0.0672	0.0666
115	0.0690	1.467	13.230	0.004312	0.0621	0.0694	0.0664
116	0.0689	1.509	13.188	0.004429	0.0618	0.0716	0.0662
117	0.0688	1.553	13.144	0.004548	0.0615	0.0729	0.0660
118	0.0687	1.597	13.100	0.004671	0.0612	0.0763	0.0659
119	0.0685	1.642	13.055	0.004796	0.0609	0.0788	0.0657
120	0.0684	1.689	13.008	0.004924	0.0606	0.0813	0.0655
121	0.0683	1.736	12.961	0.005054	0.0602	0.0839	0.0653
122	0.0682	1.785	12.912	0.005187	0.0599	0.0866	0.0651
123	0.0681	1.835	12.862	0.005323	0.0596	0.0894	0.0649
124	0.0680	1.886	12.811	0.005462	0.0592	0.0920	0.0647
125	0.0678	1.938	12.759	0.005605	0.0589	0.0952	0.0645
126	0.0677	1.992	12.705	0.005751	0.0586	0.0982	0.0643
127	0.0676	2.047	12.650	0.005900	0.0582	0.1014	0.0641
128	0.0675	2.103	12.594	0.006052	0.0578	0.1046	0.0639
129	0.0674	2.160	12.537	0.006207	0.0575	0.1080	0.0637
130	0.0673	2.219	12.478	0.00637	0.0571	0.1115	0.0635
131	0.0672	2.279	12.418	0.00653	0.0567	0.1151	0.0633
132	0.0670	2.340	12.357	0.00669	0.0564	0.1187	0.0631
133	0.0669	2.403	12.291	0.00686	0.0560	0.1225	0.0628
134	0.0668	2.467	12.230	0.00703	0.0556	0.1262	0.0626
135	0.0667	2.533	12.164	0.00721	0.0552	0.1306	0.0624
136	0.0666	2.600	12.097	0.00739	0.0548	0.1348	0.0622
137	0.0665	2.669	12.028	0.00757	0.0544	0.1391	0.0620
138	0.0664	2.740	11.957	0.00776	0.0540	0.1437	0.0618
139	0.0663	2.812	11.885	0.00795	0.0536	0.1484	0.0615
140	0.0662	2.885	11.812	0.00814	0.0532	0.1531	0.0613
141	0.0660	2.960	11.737	0.00834	0.0527	0.1581	0.0611
142	0.0659	3.037	11.660	0.00854	0.0525	0.1633	0.0608
143	0.0658	3.115	11.582	0.00875	0.0519	0.1687	0.0606
144	0.0657	3.195	11.502	0.00896	0.0514	0.1743	0.0604
145	0.0656	3.277	11.420	0.00918	0.0510	0.1801	0.0602
146	0.0655	3.361	11.336	0.00940	0.0505	0.1861	0.0599
147	0.0654	3.446	11.251	0.00962	0.0501	0.1922	0.0597
148	0.0653	3.533	11.164	0.00985	0.0496	0.1986	0.0594
149	0.0652	3.623	11.074	0.01008	0.0491	0.2053	0.0592
150	0.0651	3.714	10.983	0.01032	0.0486	0.2123	0.9589
151	0.0650	3.809	10.888	0.01056	0.0481	0.2194	0.0587
152	0.0649	3.902	10.795	0.01080	0.0476	0.2267	0.0584
153	0.0647	3.999	10.698	0.01105	0.0471	0.2245	0.0582
154	0.0646	4.098	10.599	0.01131	0.0466	0.2426	0.0579
155	0.0645	4.199	10.498	0.01157	0.0461	0.2510	0.0577
156	0.0644	4.303	10.394	0.01184	0.0456	0.2598	0.0574
157	0.0643	4.408	10.289	0.01211	0.0450	0.2689	0.0571
158	0.0642	4.515	10.182	0.01239	0.0445	0.2785	0.0569
159	0.0641	4.625	10.072	0.01267	0.0439	0.2884	0.0566
160	0.0640	4.737	9.960	0.01296	0.0434	0.2988	0.0563
161	0.0639	4.851	9.846	0.01325	0.0428	0.3095	0.0561
162	0.0638	4.967	9.730	0.01355	0.0432	0.3207	0.0558
163	0.0637	5.086	9.611	0.01386	0.0417	0.3327	0.0555
164	0.0636	5.208	9.489	0.01417	0.0411	0.3451	0.0552
165	0.0635	5.333	9.364	0.01448	0.0405	0.3579	0.0549
166	0.0634	5.460	9.237	0.01480	0.0398	0.3714	0.0546
167	0.0633	5.589	9.108	0.01513	0.0392	0.3857	0.0544
168	0.0632	5.721	8.976	0.01546	0.0386	0.4005	0.0541
169	0.0631	5.855	8.842	0.01580	0.0380	0.4162	0.0538
170	0.0630	5.992	8.705	0.01614	0.0373	0.4326	0.0535
171	0.0629	6.131	8.566	0.01649	0.0367	0.4498	0.0532
172	0.0628	6.273	8.424	0.01685	0.0360	0.4681	0.0528
173	0.0627	6.417	8.280	0.01721	0.0353	0.4872	0.0525
174	0.0626	6.564	8.133	0.01758	0.0346	0.5075	0.0522
175	0.0625	6.714	7.983	0.01796	0.0340	0.5290	0.0519
176	0.0624	6.867	7.830	0.01834	0.0332	0.5516	0.0516
177	0.0623	7.023	7.674	0.01873	0.0325	0.5758	0.0513
178	0.0622	7.182	7.515	0.01912	0.0318	0.6011	0.0509
179	0.0621	7.344	7.353	0.01953	0.0311	0.6285	0.0506
180	0.0620	7.51	7.187	0.01994	0.0303	0.6576	0.0503
181	0.0619	7.68	7.017	0.02036	0.0296	0.6888	0.0499
182	0.0618	7.85	6.847	0.02078	0.0288	0.7215	0.0496
183	0.0617	8.02	6.677	0.02121	0.0280	0.7564	0.0493
184	0.0616	8.20	6.497	0.02165	0.0272	0.7947	0.0489
185	0.0615	8.38	6.317	0.02210	0.0265	0.8357	0.0486
186	0.0614	8.57	6.127	0.02255	0.0256	0.8805	0.0482
187	0.0613	8.76	5.937	0.02301	0.0248	0.9286	0.0478
188	0.0612	8.95	5.747	0.02348	0.0240	0.9804	0.0474
189	0.0612	9.14	5.557	0.02396	0.0231	1.036	0.0471
190	0.0611	9.34	5.357	0.02444	0.0223	1.098	0.0467
191	0.0610	9.54	5.157	0.02493	0.0214	1.165	0.0463
192	0.0609	9.74	4.957	0.02544	0.0205	1.239	0.0460
193	0.0608	9.95	4.747	0.02955	0.0196	1.322	0.0456
194	0.0607	10.17	4.527	0.02647	0.0187	1.416	0.0452
195	0.0606	10.39	4.307	0.02700	0.0178	1.521	0.0448
196	0.0605	10.61	4.087	0.02753	0.0168	1.633	0.0444
197	0.0604	10.83	3.867	0.02807	0.0159	1.766	0.0440
198	0.0603	11.06	3.637	0.02863	0.0149	1.918	0.0436
199	0.0602	11.29	3.407	0.02919	0.0140	2.091	0.0432
200	0.0601	11.52	3.177	0.02976	0.0130	2.290	0.0428
201	0.0600	11.76	2.937	0.03034	0.0120	2.528	0.0423
202	0.0600	12.01	2.687	0.03093	0.0110	2.822	0.0419
203	0.0599	12.26	2.437	0.03153	0.0099	3.177	0.0415
204	0.0598	12.51	2.187	0.03214	0.0089	3.614	0.0410
205	0.0597	12.77	1.927	0.03276	0.0078	4.187	0.0406
206	0.0596	13.03	1.667	0.03339	0.0068	4.940	0.0401
207	0.0595	13.30	1.397	0.03402	0.0057	6.015	0.0397
208	0.0594	13.57	1.127	0.03466	0.0046	7.608	0.0392
209	0.0593	13.85	0.847	0.03531	0.0034	10.33	0.0387
210	0.0592	14.13	0.567	0.03597	0.0023	15.74	0.0383
211	0.0591	14.41	0.287	0.03664	0.0012	31.72	0.0378
212	0.0591	14.70	0	0.03732	0	∞	0.0373

The value of R, instead of being 53.36, is then

$$\frac{(85.8 \times 0.026784) + (53.36 \times 0.0178)}{0.026784 + 0.0178} = 73, \text{ about}$$

Effect of Temperature on Humidity—If a mixture at 100 deg., having a relative humidity of 0.60, is cooled, say to 90 deg., the relative humidity will be increased. The original 1 cu.ft. of mixture will become

$$\frac{460 + 90}{460 + 100} = 0.982 \text{ cu.ft.}$$

From the table, this mixture originally contained, and still contains 0.60 × 0.002851 = 0.001711 lb. of moisture. The maximum amount which it could contain, if saturated, at 90 deg., is 0.982 × 0.002131 = 0.00209 lb. The new relative humidity is then 0.001711 ÷ 0.00209 = 0.82. Cooling might be carried on to a point at which this figure would exceed 1.0, when some of the moisture would separate out as liquid dew. In symbols,

$$\text{New relative humidity} = \frac{p_1' w_1}{p_1 w_2}\left(\frac{T_1 + 460}{T_2 + 460}\right)$$

where

T_1 and T_2 = Initial and final temperatures, respectively;

w_1 and w_2 = Corresponding tabular densities;

p_1 = Tabular steam pressure for T_1;

p_1' = Partial steam pressure of the unsaturated mixture at T_1.

Frosts—On a cool night in spring or autumn, the probability of a freezing temperature before morning depends largely on the relative humidity of the air. If this is high any considerable cooling will be likely to increase it beyond 1.0; that is, to cause a condensation of vapor as dew. Such condensation, the reverse of evaporation (which consumes heat), liberates heat and thus tends to keep the temperature from falling further. With a stated temperature at midnight, then, other things being equal, a freezing temperature before morning is less likely to be experienced if the relative humidity is high.

Air in Jet-Condenser Practice

By Everard Brown

While most of the larger steel works and other manufacturing plants operate many engines condensing, it is surprising to note the universally poor vacuum maintained. The range seems to be from 21 to 24 in., and it is seldom one finds an installation carrying 26 in. Manifestly, this condition does not obtain from choice, but rather because of the apparent difficulty, or impossibility, of doing better with the equipment in use.

It might seem that the type of equipment employed is at fault because the jet type of condenser is preferred for general mill purposes, both for central installations serving a number of engines and for individual units. That this is not the case is evidenced by the fact that there are installations where condensers of this type, both barometric and low-level, give as good results, for the service, as the surface type.

Inquiry among mill engineers as to the reason for such poor vacuum will usually elicit the reply that either there is leakage in the exhaust piping or the air-removing capacity of the equipment is too small. To those not familiar with mill-operating conditions, the former reason will no doubt appear inexcusable and reflect on the diligence of the engineer in charge, while the latter will reflect on the manufacturer of the condensing equipment for not supplying a sufficiently large air pump. Full realization of what the mechanical department in a manufacturing plant often has to contend with will materially lessen any blame for leaky piping. The blame can be laid at the door of the condenser builder more often, because he has not given proper consideration to leakage. Perhaps one of the reasons for this is his eagerness to get the order for the equipment, and by offering a smaller air pump he can keep the price down to an attractive figure. Should he get the order and it is found that the air pump is too small, he can always claim that there is excessive air leakage. This is bad practice because the bidder takes advantage of the purchaser, who usually believes that an air pump will be furnished of sufficient capacity to take care of at least a reasonable amount of leakage.

It may also happen that the bidder is not given sufficient reliable data as to operating conditions, in which event he can only base the size of the air pump upon the theoretical quantity of air that will enter the condenser, plus a certain percentage for leakage which, of necessity, can only be a vague assumption. As a consequence, the amount of this leakage is usually underestimated and the air-removing capacity of the condenser made too small.

Proposals for a certain-sized condenser plant were submitted by three different bidders, all based on the same set of specifications. Taking the proposal offering the largest air pump as a standard, it was found that one of the other bidders offered a pump of half the capacity and the third a pump of about two-thirds the capacity, based on an equal number of revolutions for each, which is probably as fair a way of making a comparison as any, because it is a comparison of the durability of the pumps. It is doubtful if the pump having the largest air-removing capacity was large enough, so that it is obvious what the result would be if one of the smaller pumps were put in. The speed at which a pump operates controls its capacity, and in the above instance it was intended that the smaller pump should run at a higher speed, which brings up the question of relatively high maintenance cost.

It would seem that condenser builders have established certain standard sizes of condensers and air pumps for handling given quantities of steam, apparently without due consideration of varying conditions. They can, of course, estimate with accuracy the amount of air that enters with the steam and water, provided there are no unusual conditions with which to contend; and experience should have told them long ago how much additional air-pump capacity is required because of unpreventable leaks.

The secret of a satisfactory condenser installation hinges primarily on the question of air removal, which means an air pump of sufficient capacity to take care of any reasonable amount of leakage. Oftentimes this leakage cannot be prevented because of local conditions, or its prevention proves more expensive to bring about than the cost of the extra steam required as a result of a poorer vacuum. How much better it would be to install an amply large pump and run it slowly during the colder weather or when the outfit is new and more efficient, and then, if necessary, speed it up a little as leaks begin to develop or as the hot weather sets in. Such an installation will also provide capacity for future increase in load on the condenser, a contingency which often arises in mill practice where increasing the load on equipment is common.

It will require a little more steam to operate a larger air pump, but when compared to the losses due to a poor vacuum or to the cost of maintaining an air-tight system, this becomes quite insignificant. A use for this extra steam as it is exhausted from the air pump can nearly always be found if looked for; such, for example, as heating feed water for boilers, an avenue that offers a chance for considerable saving in power costs and possibly one which has been overlooked in many cases.

Test of a 16-Hp. Petter Oil Engine

By Chas. S. Salfeld

Some time ago a 16-hp. Petter two-stroke-cycle semi-Diesel oil engine, made at Yeovil, England, was shipped to this country and subjected to a series of tests by the writer. The engine is of the single-cylinder, vertical, crank-case compression two-port type, 9¾-in. cylinder bore by 10½-in. stroke and running normally at 325 r.p.m. It is provided with a flywheel weighing 1000 lb. and supported by an outer bearing. The exhaust ports open and close at 75 per cent. of stroke and the scavenging ports at 88 per cent.

The fuel-injection pump, owing to wedge regulation, commences to inject at varying times, according to the load. At maximum load this occurs at about 46 deg. before the upper dead center; at rated load about 34 deg.; and at smaller loads, still later. The end of the injection period is constant at all loads and is reached when the crank has almost completed the compression stroke, that is, about 5 deg. before the dead center. The governor raises and lowers a wedge interposed between the pump lever and the pump plunger and thereby graduates the impulses according to the load.

The cylinder head is an adaptation of the well known Hornsby-Akroyd principle. Its upper part, against which the fuel is sprayed, is uncooled but usually remains black. No hot bulb of the generally accepted term is employed, but to facilitate starting a short nickel tube is provided. Water injection into the scavenging port is furnished, although it is not supposed to be used up to the rated load.

The engine is one of several British makes which are widely advertised as being capable of operating with a fuel consumption not exceeding one-half Imperial pint, which would be equivalent to 0.6 U. S. pint, or 0.075 U. S. gal. While the writer is convinced that such economy can be and is obtained with thoroughly well designed engines of this class, neither he nor several of his assistants were capable of realizing such consumption on this particular engine. The very best they ever obtained, but not by any means the average, was 0.597 lb., or 0.0886 U. S. gal. of 42.5-deg. distillate, which is an excess of 18 per cent. The cause was not far to seek and presented itself in the unreliable performance of the fuel pump and injector. Further satisfactory characteristics of the engine are its capability of operating without water injection even beyond the rated load, its high mechanical efficiency, and the equally high volumetric efficiency of the crank-case air pump.

Particularly by eliminating the water injection have the makers solved a problem which, of late, has been a source of considerable trouble and anxiety to a number of manufacturers. This has been done partly at the expense of power output. Until early in 1912 this size of engine was rated at 20 b.hp. and water injection was used. The makers then decided to rate it at 16 b.hp. and abandon the use of the injection water. The writer operated the engine at the maximum load the governor would permit, namely, 23 b.hp., then removed the governor wedge so that more oil could be admitted, and it was evident that a considerably higher horsepower might yet have been developed with water injection.

During the principal trials the fuel used was distillate of 0.826 sp.gr., or 39.5 deg. Baumé. Tests with crude oil and with fuel oil were also made, and these will be found appended. The first named tests gave the following results:

Approx. Load	0	¼	½	¾	⅞	1	1⅓
B.hp.	0	4.025	8.1	12.3	14.9	16.45	22.1
R.p.m.	338	335	335	335	334	334	318
M.e.p.	12.6	14.0	19.6	24.6	29.2	30.1	38.5
Net i.hp.	8.45	9.3	13.0	16.3	19.3	19.9	24.25
Net mech. eff...	0	43.3	62.3	75.6	77.3	82.7	91.1
Oil per b.hp....	...	...	...	0.636	0.627	0.613	0.635

The average volumetric efficiency of the crank-case air-pump was 80.4 per cent., which was practically constant at all loads. At maximum load (22 b.hp.) the scavenging pressure was 3.6 lb. per sq.in. and the compression pressure 140 lb. The explosion pressure varied from 250 to 318 lb. and the exhaust pressure was about 28 lb.

The following test was carried out with Peruvian crude oil of 0.895 sp.gr. (26 deg. Baumé), 105 deg. F. flash point, and 18,601 B.t.u. per lb.:

B. Hp.	R.p.m.	Fuel per B. Hp.-Hr. Lb.	Fuel per B. Hp.-Hr. U. S. Gal.	
16.4	334	0.625	0.0837	With injection water
16.3	332	0.638	0.085	Without injection water
15.5	335	0.618	0.083	
14.2	338	0.626	0.084	
10.0	340	0.761	0.102	
5.2	344	1.23	0.165	
0	345	5.42 per hr.	0.726 per hr.	

The consumption of 28 deg. fuel oil (0.886 sp.gr.) was as follows:

B. Hp.	R.p.m.	Fuel per B. Hp.-Hr. Lb.	Fuel per B. Hp.-Hr. U. S. Gal.
15.9	322	0.646	0.087
14.9	324	0.676	0.091
9.5	325	0.893	0.121
5.1	334	1.33	0.18

The best consumption obtained with 12.5 deg. distillate was:

B. Hp.	R.p.m.	Fuel per B. Hp.-Hr. Lb.	Fuel per B. Hp.-Hr. U. S. Gal.	British Imperial Pints
15.1	326	0.597	0.088	0.59
13.8	328	0.606	0.089	0.598
9.85	335	0.703	0.104	0.694
5.1	333	1.456	0.217	1.435

The regularity of running was satisfactory except at no load, when considerable "hunting" occurred. This was not due to any defect in the governing apparatus, but to insufficient heat in the combustion chamber, the compression pressure of 140 lb. apparently being a little low. Nor did this "hunting" occur with all fuels; with crude oil it was altogether absent, but with fuel oil and with distillate it was distinctly noticeable. A throttle valve on the air inlet would have been a remedy, but none was provided. The exhaust was visible with all fuels and at all loads, but was in no way objectionable.

Effect of Temperature on Capacity of Centrifugal Pumps

By John Howard

At a recent test of a centrifugal boiler-feed pump an opportunity was afforded to determine the effect of varying temperatures upon the capacity. It was a standard Platt 3-in. three-stage pump, driven by a Terry steam

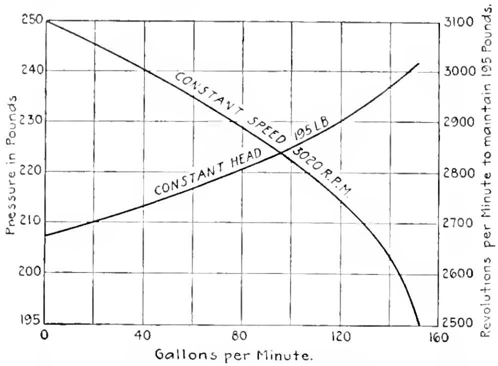


Fig. 1. Capacity Test for Constant Head and Constant Speed

turbine, and designed for 150 gal. per min. against 195 lb. pressure at 3000 r.p.m. As the head on the suction was only about 30 in. above the center line of the pump, the builders would not guarantee to handle water at a temperature greater than 180 deg. F. The water was measured by a G. E. flow meter which was afterward calibrated and found correct.

The capacity test gave the results for constant head and for constant speed, shown by curves in Fig. 1. The

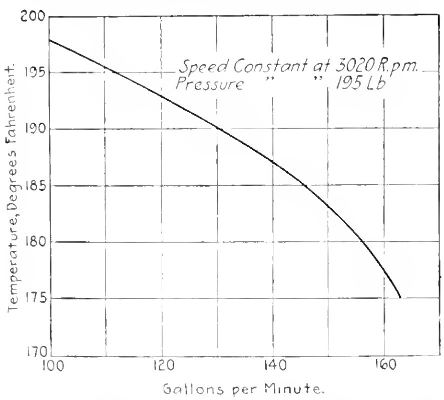


Fig. 2. Results of Temperature-Capacity Test

first curve was obtained by the use of a pump governor, and the second when the governor was cut out, the capacity being varied by throttling the discharge.

In order to make the temperature-capacity test, the temperature of the water in the open heater from which the pump took its suction was varied by controlling the amount of steam passing into it. The result is shown by the curve in Fig. 2. The great variation is undoubtedly due to the extremely small head on the suction side of the pump.

While the guarantee was for only 180 deg., it was found that by speeding up the pump somewhat, water at 190 deg. could be handled safely.

Power Costs in a Tenant Building

By Alfred A. Winter

At a time when we are all interested in figures on economical power costs, based either on theoretical calculations or test results of newly constructed uptodate equipments, I venture to show cost figures from an out-of-date plant, such as a large number of engineers have in their care. These figures are not record breaking, and no doubt some who are skilled in obtaining real efficiency will throw up their hands in dismay. But the thought that it is sometimes well to see ourselves as we really are, impels me to show our figures for 1913 and 1914.

The plant has two Babcock & Wilcox boilers (total normal rating 175 hp.) equipped with Murphy furnaces, and one deck tubular boiler, flat-grate, 150-hp. in reserve, and two high-speed, single-valve engines—one a 22x18-in. and one a 14x14-in., also a 10-kw. direct-connected unit for night lighting, as the plant runs only in the daytime. The larger engine has two driving pulleys on its shaft, one running a belt drive through certain of the buildings and one driving a 100-kw. belted generator.

The smaller engine is direct-connected to a 75-kw. generator. The power is about equally divided between shaft and electric drive and is used for various purposes of manufacturing, this being a property with tenants, to whom power is sold.

POWER COSTS FOR 1913 AND 1914

Items	1913	1914
Taxes	$562.50	$562.50
Insurance	225.00	225.00
Water rent	500.00	500.00
Coal	6,420.45	5,305.65
Labor (operating)	4,144.00	4,151.50
Labor (extra repairing)	503.45	373.01
Supplies for operating repairing—		
Oils	171.66	136.34
Packing	47.71	13.26
Boiler compound	136.50	134.62
Boiler-room supplies	51.05	68.80
Furnace and stoker supplies	264.35	.....
Pipe, valves and fittings	49.31	119.44
Lumber and millwork	.....	3.58
Sand, cement, stone and lime	.....	9.35
Electrical supplies	32.42	43.56
Tools	14.07	40.04
Hardware	.....	4.71
Miscellaneous	13.90	34.13
Repairing (outside labor)—		
Boiler, furnaces and stokers	283.10	314.13
Engineer and pumps	133.30	12.00
Electrical	10.88	24.50
Belts	7.55	.....
Roofs, spouts, etc.	.....	38.58
Stack	315.30	.....
Pipe fittings	.....	324.00
Miscellaneous	3.50	50.30
Total operation and repair expenses	$13,890.00	$12,489.00
Depreciation on $37,500 (4 per cent.)	1,500.00	1,500.00
Total	$15,390.00	$13,989.00

Horsepower	1913	1914
Generated at boilers	428	382
Loss—condensation, friction and transmission	85	85
Delivered to tenants	343	297
Cost at boilers (without depreciation account)	$32.50	$33.00
Cost at boiler (with depreciation account)	36.00	37.00
Cost delivered to tenants (without depreciation account)	40.00	42.00
Cost delivered to tenants (with depreciation account)	45.00	47.00

Operating Hydro - Electric Plants without Attendants

By J. M. Wanchope

Two power plants were recently installed by a mining company in northern Idaho, which are normally operated without attention, except once a day when the mine electrician looks them over.

The company buys most of the power used in its mine and mill, it being delivered at 2300 volts, three-phase. Having several water rights on small streams, it was decided to put them to use. One location was a short distance from the mine, where a head of 400 ft. with sufficient water to develop 150 kw. could be obtained. Another was found where, by utilizing three small streams with heads of 100, 160 and 250 ft., respectively, sufficient water to develop another 150 kw. was obtained.

The waterwheels used were of Pelton type with belt drive to the generators. As the plant had three heads, three wheels were secured to one shaft, each being adapted to a different head. The nozzle of each wheel was fitted with a deflector to direct the water from the wheel without stopping the flow.

Each plant was fitted with a common flyball engine governor, driven by a belt from the wheel shaft and so adjusted that with a rise in speed of from 5 to 10 per cent. above normal a small weight was released, which in falling released a heavy one. This was so connected to the deflector lever that the latter was moved to a position to cut off the water from the wheel, causing the unit to stop.

The generators operate in parallel with the power company, feeding into the mining company's lines on the customer's side of the meter, thus decreasing by their output the power purchased. The electric company thus provided the governing, as the generators were operated under constant load, the nozzle being set according to the amount of water available.

Automatic switches were used for the generators with no-voltage and overload trips on them. In case the electric company lost their load the effect was practically the same as a short-circuit on the small plants, due to the heavy load thrown on them. The switches would then instantly open, and the wheels and generators would start to speed up, causing the trip on the flyball governor to release the weights which raised the deflectors, thus shutting down the units. Of course, when this happened the electrician at the mine or mill knew that the load had been dropped and started the units up again as soon as the power company had returned the voltage to their line.

As the mining company was billed for the power used partly on the maximum amperes drawn from the line of the power company as determined by a graphic ammeter, it paid the mining company to keep the peak as low as possible. The two plants were operated with a leading power factor up to the capacity of the generators in current, to keep the current drawn from the line as near unity as possible, the mine load being composed of induction motors and naturally lagging. Power-factor meters were installed at each plant and in the substation of the power company on the mining company's feeder. The plants operated nicely under these conditions. There would have been no returns if an attendant had been kept at each plant, but under the conditions as stated they returned a fair interest on the investment.

Just for Fun

[More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.]

Still Thirsty

A chief of a small electric-light plant, being somewhat dry on sundry occasions, decided to tap the line leading to his boiler-feed pump, where cool palatable water was being handled. What was his surprise to find his dipper dry! He had tapped the suction which operated under 12 or 14 inches of vacuum.—*J. W. Fowlkes, Denver, Colo.*

Now It Surely "Has Came"

El Dorado Republican and Weekly Nugget

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A STEAMLESS ENGINE, A NEW POWER MOTOR

After the horseless carriage and wireless telegraph now comes the steamless engine, a rotary power motor that revolves of itself without the aid of steam heat, oil, gas or electricity, or any other external source of energy, and gives forth power that can be employed and made use of.

It could be called a "wheel within a wheel" motor, or a "planetary" motor, as, like a planet of the solar system, it revolves of its own momentum. It is in the shape of a flywheel or pulley and turns on an axis or shaft, being practical and efficient and simple of construction. It is called the Burr Evans Motor. The inventor is a practical mechanical and mining engineer now in Placerville.

The motor can be made of any size desired, from one inch to forty feet or larger in diameter. The smaller sizes will keep clocks wound-up and furnish power for any and all purposes about the home and farm. When a large amount of power is required, to operate for instance a large electric generating or pumping plant ten or more of the larger size motors can be attached to one axis or shaft. The medium size motors, from one to five meters in diameter, will be the most used on and about farms and for pumping water cheaply to irrigate lands to raise food-stuffs and for compressing air for mining and mechanical work.

The cost of operating the motor is infinitesimal. After the principle involved, that causes the motor to revolve, is understood, it is plainly evident that it will operate and supply power. As a cheap power producer it will be a great and lasting benefit to mankind in general. It is so simple that the wonder is not that it has been thought of, but that it has been delayed so long.

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A New Power-Creating Motor. No External Energy Required.

A machine, that could be called an "Automatic Fly Wheel Power Motor," which will supply power at a very nominal cost per horse power, has recently been perfected. It creates energy automatically on about the same hypothesis as water is raised gradually from the ocean surface upward and floated as clouds in land and dropped as rain, which eventually falls in a large body as at Niagara and creates power, and then returns to the ocean sea and rises again and thus goes round and round as it were, producing power each time on its downward course. Thus it is with the Burr Evans Motor.

The machine is based on an entirely new principle of an automatically revolving flywheel, which of its own momentum gives forth power in any quantity desired according to the diameter of the motor, which can be from one inch to fifty feet or more. And where a large amount of power is required, twenty or more of the larger size motors can be placed on one center shaft.

After the motor is placed in operation the cost of producing power will be only the ordinary wear and tear of the machine, which can be cut down to next to nothing per horse power by using the modern hard and tough metals and self oiling ball bearings in the construction of the machine. The motor can be made in quantities at a very reasonable cost, and it requires no care or attention when in operation.

The motor will be especially useful and beneficial to mankind in general for generating electricity at a nominal cost at any place in small or large quantities, and for pumping water cheaply for irrigating farm lands to raise foodstuffs for the increasing millions of human beings.

The inventor, Mr. Burr Evans, is a practical mechanics and mining engineer and is now at Placerville.

It is true of most discoveries that after they are brought to light they are almost self evident. Thus it is with the Burr Evans Motor.

Mountain Democrat

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SATURDAY, FEBRUARY 20, 1915

Achievement

In the February (1915) issue of "Arches," a monthly journal published at Ruskin, Tenn., there is an article headed "Achievement," from which the following is an extract:

"So much has been accomplished lately, and in such a short time that no one dares to say that anything is impossible, for so many of the things that are in every day use, were once—only a short time ago—said to be impossible. But today we are used to seeing the impossible accomplished."

Thus it is with the Burr Evans Automatic Fly Wheel Power Motor, at first thought it may seem impossible that the Motor will operate of itself as claimed, but like the sewing machine, the wireless, etc., after the principle is seen and understood, it looks simple and a matter of course, and the only wonder is that it was not thought of sooner.

In the same issue of said journal is another article in regard to obtaining energy direct from coal, in which it is stated as follows, to wit:

"When it is attained, an almost incalculable addition will be made to the mechanical energy employed by man. The idea of taking power direct from its natural sources is in accord with the spirit of the age. We are becoming impatient of the old, indirect, cumbersome ways, and what is more important, we are beginning to appreciate better the wastefulness of many of them. But in the case of coal it would seem that still another step would be made which would carry us back of coal itself to the source of energy that we find stored in it. *That source is the sunshine.*"

And Sunshine is simply diffused electricity held in suspension in the atmosphere as it were, and all it requires is an electric generator, operated by some inexpensive method, to gather in and consolidate this electric-sunshine energy in any quantity desired to be used for *Power* at any place and at any time. And the Burr Evans Automatic Flywheel Power Motor will supply the inexpensive method with which to continually operate millions of electric generators at every place in the world where power may be needed.

(Reproduced from clippings received anonymously)

Where the Water Went

It is necessary to carry a rather high pressure of steam at the Depot building here, and the water comes back so hot that steam comes out of the overflow, which I can close, as it is in the boiler room.

One night, while I was cleaning fires, the tank ran dry and I opened the make-up valve, leaving the overflow closed, which backed the water up in the return pipe. On discovering my mistake I opened the overflow and relieved the pipe. In the meantime the car inspector had tapped the pipe in the building to heat wash water and, having placed his bucket of water and turned on the steam, stepped outside a moment. On returning he found the bucket empty, and accused his partner of emptying it. Although he is supposed to thoroughly understand steam heat, he still contends that his partner, instead of the engineer, emptied the water.

This is amusing, but not the most stupid occurrence that has come under my observation.—*Willis W. Nelson, Spokane, Wash.*

A Leaning Chimney Plumbed

By Thomas S. Clark*

Many methods have been employed to bring back to the vertical position tall columns such as chimneys, shafts, towers, and the like, which have leaned or settled out of plumb. The procedure has often been very expensive and hazardous as well as slow. In the case of chimneys it has compelled shutting down the boilers and a consequent loss in output of the manufacturing plant. A new, unique and inexpensive method was recently employed to straighten quickly a 100-ft. factory chimney in Brooklyn, N. Y., without interruption to the plant.

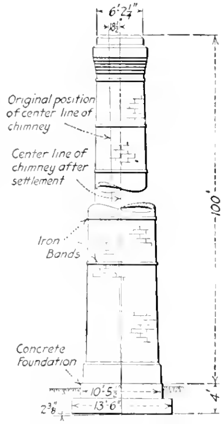


Fig. 1. Leaning Chimney in Brooklyn, 100 Ft. High

The Problem

Under one side of the foundation the soil had softened, and settlement had taken place, due to leakage from a water pipe near the foot of the foundation, whose existence had been forgotten. Fig. 1 shows the leaning chimney.

To excavate on the low side of the foundation to the depth of the footing course, crib under it, and attempt to jack the structure back plumb, would have involved large cost, loss of time, and not a little risk. The great weight of the 100-ft. column and the additional pressure due to the leaning would have required powerful jacks and a substantial footing to jack against. There would have been danger also of cracking the unreinforced spread foundation, and additional foundation would have had to be placed before the jacks and cribbing could have been removed safely.

Another method to straighten a leaning chimney, employed to some extent in Europe, is to saw out a course or a portion of a course of brickwork on the side of the columns away from the direction of lean, in wedge-shape, with an ordinary two-man crosscut saw, and allow the portion of the chimney above the cut to settle back. This method is, to say the least, not entirely satisfactory nor does it remedy the defect entirely, as the portion below is still out of plumb and the bearing surface of the foundation footing is not brought to the horizontal. For these reasons these two methods were abandoned.

The chimney was in operation, so it was not possible to determine the amount of its lean by plumbing to a center on the inside. The deviation from the vertical was therefore determined with a transit by a simple triangulation; it was found to be 18½ in. From this figure, with the known height of the chimney, it was determined that the toe of the footing on the high side must be settled 2⅜ in. on a line exactly opposite the direction of the lean. The problem was to remove just enough earth between the center of the foundation and the toe of the high side to gradually settle the foundation back 2⅜ in. at the toe. Levels were taken on the high side and an indicating plumbline fastened to the side of the chimney.

How the Work Was Done

A trench was excavated on the high side to the depth of the foundation, about 4 ft., the length of the trench equal to the square side, and its width equal to half the width of the foundation, or about 8 ft. Four 2-in. wrought-iron pipes, 8 ft. long (half the width of the foundation), were sharpened sawtooth fashion at one end. These pipes were successively driven under the high side of the foundation near its center (Fig. 2), then withdrawn, and emptied of the material in them by driving a steel rod through the pipe. Successive insertions were made about a foot apart. As the pipes were withdrawn, the adjacent earth crushed into the holes left.

In this way but a small quantity of earth was removed at a time, and but a small quantity gave way at a time; the yielding occurred just where wanted. The chimney settled back gradually, with no shock or no danger. The amount of settlement, its direction, and the rapidity of settlement were always in absolute control. The telltale plumb-bob gave the direction as well as the amount of movement.

At one period of the operation the chimney began to settle slightly out of line. It was only necessary to drive the pipes more often at a certain point to bring the shaft back to line.

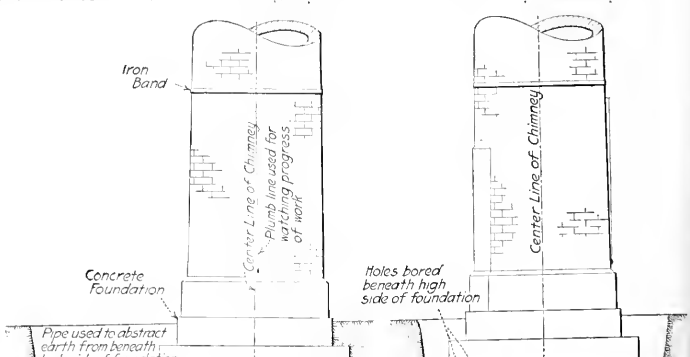


Fig. 2. Method of Removing Earth under High Side to Bring the Chimney Back to Plumb

When the column was again plumb the trench was filled up. The underground leak in the drain pipe had been previously stopped to prevent further softening of the earth on one side. The chimney has since remained intact.

The work was done by the Alphons Custodis Chimney Construction Co., of New York. The method was devised by the writer.—*Engineering News.*

*Engineer, Alphons Custodis Chimney Construction Co., 99 Nassau St., New York City.

Editorials

The Engineer at Public Hearings

Operating engineers seldom have to address legislative committees, public-service commissioners or municipal officials in formal hearings, but when they do it is worth while to know how to do it. As a class, engineers are men of deeds rather than of words, while lawyers are fairly characterized by the latter qualification. It is not easy to carry a petition successfully through a public body, and the causes which tend toward failure in this direction deserve careful consideration.

Engineers seeking legislation or other regulatory action must first of all present their cases upon the solid foundation of facts. Hearsay evidence cuts very little figure with the average committeeman, but a few essential facts and figures throwing light upon the problem in hand, set forth in a plain, logical way, will do wonders in commanding a respectful hearing. Often it pays, no doubt, to club together and retain counsel to look after the legal side of proposed measures; but above all, it is essential to stick absolutely to known facts and conditions and not to attempt to strengthen the case by introducing evidence of uncertain nature. It is better to say "I don't know" a hundred times in a forenoon before a committee, when the witness or proponent of a measure is not fully informed, than to try to "bluff through" on suppositions—a lesson that is none too easily learned in other walks of life.

A fair degree of consideration for the views of one's opponents is desirable, so far as it does not jeopardize the objects of the petitioners. Thus, a bill may be drawn to limit central-station rates in a way that will make life more tolerable for the plant engineer. The latter ought to be able to gain his object without attacking the desirability of giving existing capital a reasonable return. In advocating any measure the proponents ought to be prepared to meet the question of its effect on present business organizations. One of the greatest defects seen in legislative committee rooms is the inability to see more than one side of a question—a defect which narrows the character of evidence presented and often leads to disaster when the finding comes through. The engineer cannot be expected to present a case with the skill of a Webster or a Choate, but he can certainly make sure of his facts and stand on those, even in the face of severe cross-examination. Restraint in advocating any cause goes further than excessive one-sidedness.

Recent observation of the work of engineers in hearings emphasizes the importance of presenting only pertinent data, of avoiding tempting side-issues and personal grievances not affected by the proposed measures, and of putting in evidence bearing toward a definite demonstration of the need for a given bill. The burden of refuting a measure may be thrown upon the engineers' opponents in many cases. The avoidance of needless work is as important as the presentation of facts bearing directly on the matter in hand. Mere assertions that a bill is desirable count for little. Coöperation is absolutely essential in "framing up" a proper line of attack in supporting legislation on behalf of the engineer, and simple, direct methods are invaluable in dealing with public authorities.

There Is No Royal Road

Knowledge is not to be found by waiting with idle brain and hands. Knowledge may be acquired only by those whose desires are sufficiently strong to urge them to make the effort, both mentally and physically, to win it. The fields of knowledge are unfenced. There are no barbed-wire entanglements to obstruct the way, no trenches across the road, to be won only by fixed bayonets and the strenuous charge or spectacular bravery. Neither is the road to knowledge the velvet-covered royal way made smooth by the toil of others. He who seeks must build the road for himself. Each step means the expenditure of time and effort, with no limit upon the results that may be attained, except the self-imposed limitations of the seeker.

The means of acquiring knowledge are within the reach of all. Free libraries and reading rooms are open to all who care to enter, and in them may be found books and periodicals covering almost every subject. Attendants are there who will inform the seeker where he may find books and articles upon the desired subject. A letter, costing two cents to mail and inclosing a stamp for a reply, will bring an answer or suggestions as to where the answer to nearly any question may be attained, not obtained. The printing press has made books low in cost, and reasonably few are required to cover any one line of research. But no book is of any use until taken from the shelf and opened. Ages ago someone said, "You must creep before you can walk, walk before you can run." The aviator does not jump into his machine and immediately reach the height of the clouds. The tower is not started at its full height and built down to the ground.

In building the tower the first step is excavating for its foundation, by clearing away the soft, springy surface to a firm footing. A foundation must be laid before the builders are ready to start on the tower. The aviator starts his machine on the ground and gradually rises. In learning to walk each step in advance must be made by itself and completed. There is no short cut; no royal road. Experience is the only real teacher. The higher branches of any subject cannot be understood until the beginner has learned to understand the fundamentals of that subject, has learned to reason, and each one must learn to think for himself. No power outside of the individual can cause his brain to work. No power can teach unless the brain is ready to receive and able to understand. One may be able to repeat a rule, parrot-like, word for word, but unless the reason for that rule is clearly understood it is of little value, for it cannot be applied with intelligence.

Charting the Plant

How many engineers can show a blueprint or any kind of a plan of any portion of their plant, or of any of its equipment? How many have a list of the machinery in their plant, giving information in regard to its size, date of installation, make and purpose? Yet without these, they cannot promptly answer requests for information from the head office.

Construction plans showing the relative locations of pipes and the different pieces of apparatus, of electric-wiring ducts and panel boards, of valves and the purpose they serve are often laughed at when the apparatus is installed. They help, however, in later locating new equipment without interference from a long forgotten sewer or buried pipe line. It is often hours and weeks before the new man on the job is broken in and can perform all the duties of his position without questioning one of the older men. In the one-man plant many tedious hours are spent in doping out the various lines of pipes and their valves. Many a shutdown is caused by the lack of some simple little diagram or plan, one that a man could make in a week or even a day. What the lack of that plan costs can only be measured by the size of the plant affected. One man's time for a week may be forty hours, which is the same as forty men losing one hour each, or four hundred losing six minutes each. And six minutes is a very short shutdown.

The lack of plans is rarely the fault of the engineer, the man in charge of the plant. He often has all that he can do to keep it running. Lack of plans is due to the endeavor to cut down cost, that terribly high first cost, and often to trying to save time, because it would take too long to make a drawing to scale. No one seems to realize that if the scale drawing is not made in the office before construction, a full-sized model is built in the field by cut, try and fit methods. You can get out of paying for the drawings, but you cannot escape paying for the unnecessary waste of time caused by the lack of drawings. True, you may not be able to see the amount you pay for measures made in the field, for cutting and fitting, but pay you do, either in money or in time, not only in the first cost, but in upkeep, in making repairs.

Lubricants

Lubricating oils are made up from a few easily obtainable base oils or greases. The number of combinations and their proportions are unlimited, but the function which each ingredient has in the compound appears to be unknown to the purchasing public. We do not know exactly what qualities are improved by adding certain oils, or whether what are popularly known as adulterants may not be better than the oils with which they are mixed. Knowledge of this kind can only be gained by long and careful test, the expense of which no one firm should stand.

If a consumer understood why John Smith's No. 3XX oil is all right in the heat of a closed engine room, but refuses to work after the room is properly ventilated, he could discuss the oil question more intelligently. As it is now, oil is bought on representations of the most general sort and on the trial and error system. There is not always a certainty that the same brand of oil does not change while it is being stored by the purchaser. Who knows what the effect may be of pouring a new barrel of oil into a tank in which there remains a few inches of some old oil, especially when he knows the composition of neither? There may be chemical changes going on even with mineral oils. We can be confident that there are changes with time if the oils are of animal or vegetable origin.

This is a serious problem. It is not so much that the saving in oil would amount to much. It would not, but the saving in power is important. Power is mostly generated to be transformed into heat by way of friction. In some sections of the country power costs so little that it has hardly to be considered, but generally, the engineer is held responsible for the size of the coal bill, and a man who can cut the consumption is worth more than one who does not take into consideration all the possible wastes that may be going on. In some plants the engineer's responsibility is assumed to end at the door of his plant, but most owners would welcome his assistance in reducing costs, even to his suggesting the oil to be used in the shop or mill. The man whose pay envelope depends on the low cost of power has a right to ask that every precaution be taken to see that his power is intelligently consumed.

This problem is too large and of too universal interest to expect that any one maker of oil will shoulder the burden. Some university or other public institution should assume it. We know much about oils, but our knowledge is based more on their manufacture and chemical composition than on physical tests, and while the composition of an oil may be duplicated if known, it is its physical properties that interest the engineer.

Dissatisfaction in Massachusetts

If the present engineers and firemen's license law in Massachusetts is so woefully wrong and objectionable as the supporters of the new license bill would have us believe, it seems strange that it should have taken about twenty years to find it out.

No matter how good a law may be, it will not find universal favor. The present law in Massachusetts may have its little defects. Even so, why should a new bill be introduced? Are amendments to the present law, where needed, impossible? Those for and those against the bill now before the Massachusetts legislature should know that the function of license laws is to promote public safety. With this in mind as the fundamental basis to work on, the present situation ought to be easily adjusted to the satisfaction of all without destroying a law which, on the whole, has been long and widely recognized as good.

The letter, "Live Steam vs. Live Men" on page 412, is printed, not because of its news value, for there is nothing unique about it, but to call attention again to the dangerous conditions that are permitted to exist and the necessity for regulations which will prevent them. How naïve the observation that "It (the bill) was supported by a number of engineers and opposed by a number of manufacturers."

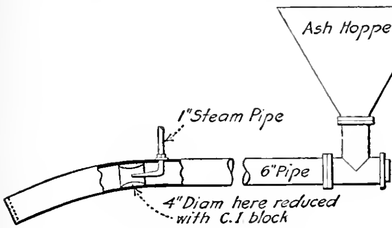
"Aye, there's the rub."

When a daily paper thus throws its influence against a good measure, it is only natural that its motives should be questioned.

Correspondence

Live-Steam Ash Ejector

E. H. Clarke inquires in the issue of Dec. 22, 1914, as to why his ash ejector will not work. I believe that if he will plug the end of the 6-in. pipe at the hopper end and fit a nozzle about 7/8 in. diameter, as shown in the illustration, about three feet from the discharge end, he will get



Vacuum Ash Handler

over his trouble, as it is far easier to draw ashes out by a partial vacuum than to blow them out. At the same time, I think that less steam will be taken with the suction outfit, although steam ash ejectors of any type are very wasteful and should not be used if it is possible to use an elevator or conveyor.

E. R. Pearce.

Rochdale, England.

Protecting Dry Batteries

Dry batteries are used extensively for operating bells, tank signals, ignition work on engines, etc., and to many engineers it is a constant source of worry to keep them in good condition. The nature of the work demanded of the batteries often calls for their use under damp, hot, dry or other unfavorable conditions. The life of the average dry battery depends more on the conditions in which it works than on the actual current drawn from it.

The writer has adopted the scheme of protecting batteries from dampness and changes in temperature by covering them with paraffin, the results being not only increased life of the battery, but also increased efficiency. All that is necessary is to secure a light wooden or even pasteboard box large enough to hold the required number of cells and sufficiently tight to hold melted paraffin. The box should be of such a shape that the batteries may be set on end with about half an inch between cells, and deep enough so that they may be covered completely, including binding posts and connections, to a depth of at least half an inch. The batteries should be connected as usual and the terminal wires led outside the box where a switch may be connected if desired. Paraffin is then melted over a steam bath or in a double boiler and the box filled. It should be remembered that the paraffin will shrink in cooling, and for this reason it is necessary to cover the batteries to a considerable depth to insure their being completely covered after cooling.

A set of cells fixed in this manner is waterproof and proof against drying out. They will last at least twice as long as they would if not covered. The writer has records of sets that have given service in ignition work for from sixteen to twenty months. For bell work they should last longer. The cost of covering the batteries in this manner is very small. Any suitable-sized box may be used and the cost of paraffin is not over twenty-five cents for a set of four batteries.

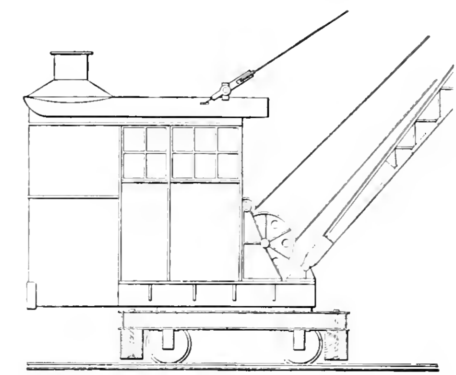
James H. Beattie.

Washington, D. C.

Operating a Locomotive Crane

On a locomotive crane which I was operating, the bottom of the truck frame was about 24 in. from the top of the rail. When the wheels jumped the track the first thing to strike was the bottom of the axle boxes, and the weight of the apparatus (about 70 tons) would fall on the boxes on one side, meaning that two new boxes (if all four wheels went off the rails) had to be replaced before the crane could be operated again, beside letting the crane sink down to the axles, as the track was laid on filled-in ground.

To overcome this difficulty I used two timbers that were in the old lumber pile and bolted them fast under



Timbers under Crane to Prevent Damage and Facilitate Replacing when Derailed

the truck frame, leaving about a two-inch clearance between the bottom of the timber and the top of the rails. When the crane jumped the track again it could only sink two inches and rest on the timbers both back and front. After that it was only necessary to swing the loaded bucket over the rails, raise it to the top of the boom and lower the latter till its weight together with that of the bucket overbalanced the back end of the crane. Then when the wheels were clear of the rails, by setting a jack or a heavy block on a slant against the side of the frame and raising the boom, the crane would tilt over and the wheels would fall back on the rails. When one end was on the rails the position of the boom was reversed and the same operation performed on the other end.

Instead of taking four or five hours with five or six men, as formerly, to get the crane back on the track, it takes about fifteen minutes with one man besides the operator. No heavy lifting, no broken boxes, and little loss of time.

JOHN H. HONEY.

New York City.

Cost of Operating Vacuum Ash-Handling Systems

In the Feb. 9 issue of POWER the Girtanner-Daviess Co. revives the discussion on the cost of operating vacuum ash-handling systems, which was carried on in the issues of July 7, Sept. 8 and 15, and Oct. 20 of last year.

In this discussion the error is made of assuming that repairs and depreciation are synonymous. The yearly repair cost of $32 is compared with the 40 per cent. depreciation of the system given in my previous discussion. The fact that the cost of repairs for the first year is but a nominal sum is no assurance that the equipment will not go down in the second year of its operation. To get at the actual rate of depreciation, the two years and more would have to be considered. Any system of accounting that does not take into consideration all the items comprising the cost of ash removal, and that over a number of years, is going to prove misleading.

While it is true that my experience with the vacuum system of ash removal was limited to a single installation, and that of the blower type, it nevertheless gave me a good impression of the abrading power of swiftly moving ashes on iron and steel pipe, with its consequent effect on the cost per ton of ash removal.

From an operating standpoint, success or failure of a vacuum ash-handling system depends on the amount and composition of the ashes. An installation that is considered a success in the East where a low-ash coal is available may prove a failure in the West where coal running upward of 20 per cent. ash containing a high proportion of silica is frequently encountered.

There is no denying that the vacuum system of ash removal is a convenience so far as the labor of handling is concerned, although pulling and breaking clinker into a 6-in. hole is not so convenient as pulling them into a bucket conveyor or car, and if the cost can be kept down to a reasonable amount, the vacuum system should soon prove itself the champion in its field. Personally, however, I do not look for its general adoption.

C. O. SANDSTROM.

Kansas City, Mo.

The article in the Feb. 9 issue emanating from Messrs. Girtanner-Daviess is interesting reading. Discussion of engineering questions, however, in an engineering journal should be accompanied by such array of data as will be really informative to engineers. The information given in the letter referred to does not constitute engineering data, but I trust that from the experience of Messrs. Girtanner-Daviess such data may shortly be forthcoming so that engineers may receive some much needed information concerning a system or plan which has its undoubted merits.

GEORGE L. PRENTISS,
Parson Mfg. Co.

New York, N. Y.

In reply to the above letters by Mr. Sandstrom and Mr. Prentiss of the Parson Manufacturing Co., we have the following to offer: Since our last letter we have had the opportunity to investigate one of our systems and find that in the straight pipe, hoppers and all parts against which the ashes do not directly impinge the wear is not excessive. Over 18,000 tons of ashes, clinkers and coke passed through the line in ten months and the wall of the straight pipe was reduced less than 1/8 in. In the bends of the pipe, which are made in four sections, the second section, which leads from the straight line into the curve, is the one that shows the most rapid wear. In this case over 2500 tons of ashes passed the given point before replacement was necessary. The cost of replacing this section is about $10, or 0.4c. per ton of ash handled. It was not necessary to replace the other sections in this particular installation, although 8000 tons has been the limit in other installations.

According to the above data it is estimated that the straight pipe is good for the conveyance of at least 200,000 tons of ashes, and on this basis the depreciation would be about 10 per cent. on the line. This, of course, represents maximum operation, and where the service is less the life of the straight pipe, made from specially hard chilled cast iron 1 in. thick, would be indefinite. In other words, the installation on a 7- or 8-ton-per-day performance, would last longer than the boilers or other equipment which it serves.

Some of the points mentioned by the parties discussing this subject are based on ordinary pipe of the usual thickness which costs more per pound and wears out more quickly, requires additional labor, costs more for upkeep and depreciates more rapidly.

If there is any further information desired, or any direct inquiry made, we shall be glad to give specific data on installations in operation for 18 months.

R. H. MILLER,
Girtanner-Daviess.

St. Louis, Mo.

Live Steam versus Live Men

Here is a copy of a clipping taken from our local paper four years back:

> A hearing was held Friday before the committee on labor on the bill which provides for the licensing of steam engineers and the appointment of a chief engineer with a brood of assistants—all drawing live steam from the state treasury. It was supported by a number of engineers and opposed by a number of manufacturers. The committee is expected to blow the whistle for the recall of this bill.

And here is a bit of personal experience in our own city of very recent date by a local engineer:

With a friend I visited a neighboring power plant in which a boiler fifteen or twenty years old was doing duty. The first thing that I noticed was a lever safety valve supporting at the outer end of the lever, not only the weight which went with it, but a six-quart pail containing a varied assortment of bolts, old iron, etc. For the uninformed I will say that this would hold the steam in the boiler to a pressure perhaps twice that for which it was built, or even more, when from its age the pressure should probably not be allowed to exceed two-thirds that for which it was originally designed. Being curious, I asked the engineer (?) what steam pressure he carried. He took me to the steam gage and rapped the pipe a number of times; the pointer each time would find a new position, showing that it was out of order. Also, there was a gage-glass and only two gage-cocks, but as there was a lively fire under the boiler, I did not care to ascertain if they were working properly, so took a hurried departure, inviting my friend to come along and fearing for the safety of the 25 men working within one hundred feet of this "live steam" which threatened their lives through the gross carelessness or ignorance of the man in charge, the owner or both.

Would it not be well to have a boiler-inspection and engineer's license law on our statute books before we attend the funeral of a friend, or perhaps a son or brother, killed by a boiler or engine accident, even if those who enforce it do draw "live steam" from the state treasury?

I will vouch for the above facts, substantially as presented.

A CONNECTICUT ENGINEER.

Bristol, Conn.

The Diesel Engine Defended

In the article on "Oil Engine Tendencies" in the Feb. 9 issue we note among the objections which can be raised against the Diesel engine that "it is complicated in design, necessitating strict attention to the minutest details and requires a very high grade of workmanship." We are led to wonder why, and since when, have sound workmanship and conscientious care and attention become objectionable. Surely, it is one of the great merits of the Diesel engine that those who build it thoughtfully bring to bear upon its production the best of brains and labor. No complication of design requires this; the engine is essentially simple. This accuracy of construction and honesty of material and workmanship are demanded by the higher pressures in this class of engine.

By years of experience the reputable and more practiced Diesel-engine builders in Europe have eliminated the troubles first encountered with these higher pressures. The correct practices in four-stroke-cycle design have long since been firmly established, and it is of this knowledge that we availed ourselves when we became the sole licensees of the Swedish Diesel Engine Co., a firm with 17 years' specialized experience.

It is correct to state that close adjustment must be maintained at all times, but Mr. Ward goes astray when he adds that skilled attendance with corresponding high cost is essential. The adjustments are extremely infrequent, for the wear upon these engines is so slow that it does not become sufficiently pronounced to need attention in less than 10,000 operating hours, and frequently more.

The only requirement of the attendance is that it shall be intelligent. The distinction between the terms "skilled" and "intelligent" is important and must be observed. The one implies high wages and difficulties of supply; the other brings the attendance to an ordinary level. With the simple instructions we are issuing for the care and maintenance of our Diesel-type engines any engineer of average clearheadedness will be able to operate them with a maximum of satisfaction, obtaining prolonged and economical service.

The estimate that between 400,000 and 500,000 hp. in the aggregate is supplied by Diesel engines in Europe is far from the mark. The writer made a close computation about 12 months ago and arrived at the total of 1,800,000 hp., but by this date the figure will have been exceeded. The firm which made of Diesel's project a practicable engine and translated his ideas into a sound commercial prime mover has itself sold over 400,000 hp., or as much as Mr. Ward estimated for the lower limit of the total European output.

R. W. CROWLY,
McIntosh & Seymour Corp.

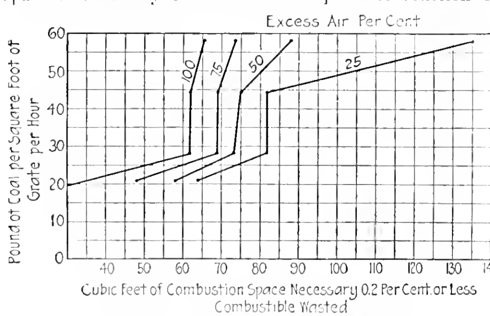
Auburn, N. Y.

Bureau of Mines Paper on Combustion

I have carefully studied the Bureau of Mines Technical Paper No. 63, on "Factors Governing the Combustion of Coal in Boiler Furnaces," and find it interesting. The object and scope of the investigation promise information that engineers are eager to have. It is true that there is a lack of knowledge of the underlying principles of correct furnace design, but perhaps when this investigation is completed there will be available information really useful in practice.

Recorded results show that practically the same amount of combustion space is required for burning both 28.4 and 44.3 lb. of coal per square foot of grate per hour. This is the case for all percentages of excess air. This is more noticeable when presented graphically as shown herewith. It requires about 40 per cent. more combustion space to produce 0.2 per cent. or less combustible in the gases, at a combustion rate of 21 lb. per square foot than at 28 lb.; therefore, it does not seem reasonable that it would require the same space for a rating of 44 lb. as 28 lb. Also, above 44 lb., as is shown by the chart, the space required increases.

This paper shows that a long and spacious combustion space is necessary to allow for complete combustion of the gases and increased efficiency.



CURVES FROM BUREAU OF MINES PAPER

From the bulletin's illustration, Fig. 10, on the variations in furnace conditions during test No. 121, it will be noted that the average temperature at section *G* was about 300 deg. F. less than at section *A*, a distance of about 29 ft. Upon referring to the data on this test it will be found that the rating was exceptionally high, 61 lb. per square foot. Also one figures that the loss caused by the drop in temperature amounts to more than the loss that would result from incomplete combustion.

Furthermore, this loss due to a restricted combustion space occurs for short periods during peaks and would not balance the floor space and investment and maintenance cost of space necessary for complete combustion.

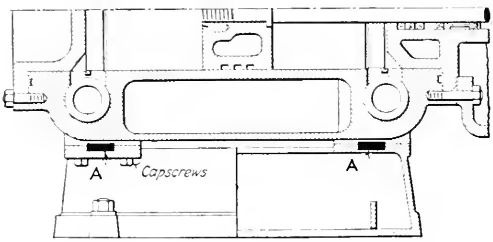
Information on the amount of combustion space needed for certain grades of coals burned at certain ratings is necessary if we are to calculate the investment and maintenance costs.

Meridian, Miss. CHARLES M. ROGERS.

Replacing Broken Capscrews

The letter by C. L. Juno regarding broken capscrews, on page 891 in the issue of Dec. 22, reminds me of a somewhat similar job.

One day it was noticed that one ammonia compressor fastened to its pedestal base with twelve 1¼-in. capscrews was moving a little and that three of the capscrews were broken and most of the others loose. The machine was



KEYS TO TAKE STRAIN FROM CAPSCREWS

shut down, the broken pieces drilled out, as we had plenty of room and good tools, and new capscrews put in.

We soon found two more broken ones, and as time went on it was a common thing to find broken or loose capscrews, and to hold those two compressors steady became a troublesome problem, although we made a new set of capscrews with bodies a snug fit in the holes through the pedestal. Finally, slots *A* were cut 1 in. deep and 3 in. wide at both ends on both sides, making 1x3-in. slots, or keyways, one-half in the pedestal and the other half in the cylinder flange, and extending clear across.

Tight-fitting keys were made and driven into these slots after the capscrews had all been pulled up as tight as possible. This cured the trouble, as the strain was on the wedges instead of on the capscrews.

Chicago, Ill. A. G. SOLOMON.

Mr. Williams' Rejoinder

In the Mar. 2 issue a reference is made to the Hall of Records' test, under the title "Some Dates to Remember," which suggests, at least indirectly, that the New York Edison Co. is endeavoring to withhold the results of the test from publication. On the contrary, we have repeatedly urged that the report be completed and signed at the earliest practicable moment. The test—probably the most complete ever made of a private plant—was conducted under the supervision of a committee consisting of some of our most eminent practical and theoretical engineers, as representatives of the City, the Bureau of Municipal Research and ourselves.

Numerically, the representatives of the Edison company on the committee are in a minority. Quite apart from this, however, the character of those who have been in charge of the proceedings should preclude any suggestion of influence, undue or otherwise, concerning their final action, whether in favor of or against the operation of the private plant or the service of this company. After the completion of the test, some time has been required for analysis and study before the preparation of the report. All this we understand is now practically complete, and it is expected that the report will soon be ready for publication.

Knowing that you would not even unwittingly do injustice either to the gentlemen who have given so much time to this important question or to this company, we feel that you will take such fair means as may be necessary to avoid misunderstanding, through inference or otherwise, from the editorial in question.

ARTHUR WILLIAMS,
General Inspector, New York Edison Co.

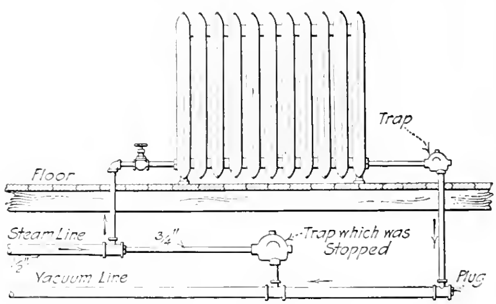
New York City.

[We are glad to learn that Mr. Williams is as anxious as ourselves to see the report on the Hall of Records' test made public. The impression is current that the representatives of and sympathizers with the Edison company on the committee, through zealous efforts to serve their clients' interests, were largely responsible for the delay.—EDITOR.]

Why a Radiator Would Not Work

In part of a direct-heating equipment, a two-pipe radiator connected to a vacuum return system failed to heat. There was about one pound pressure on the steam side and about three inches of vacuum on the return line.

At first the case seemed puzzling, especially as the admission valve and the thermostatic return-end trap proved to be unobstructed and all the other radiators in the building were heating nicely. An examination of the lines leading to this particular unit showed that it was the end one of the series. In other words, it was fed by the



TRAP PREVENTING CIRCULATION OF RADIATOR

extreme end of the steam line and tapped by the extreme end of the vacuum or return line.

As shown in the sketch, a trap had been installed in a jumper across the space beneath the floor where the radiator was, the supposition being that the arrangement would keep this extreme end dry. However, when the cap cover was removed from the trap an old lead pencil was found firmly wedged under the thermostat. This, of course, propped it up and completely destroyed its function. A short-circuit was thus formed, shunting the heating unit entirely. When the obstruction was removed, the trap closed and the radiator promptly warmed up.

Philadelphia, Penn. EDWARD T. BINNS.

Incorrect Diagrams from Compressor

The ammonia compressor was a vertical, two-cylinder, single-acting machine with two cranks at 90 deg., driven by a water turbine. Only one ammonia indicator

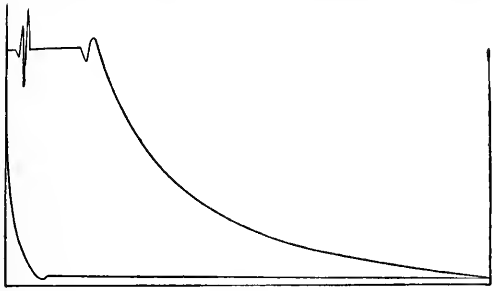


Fig. 1

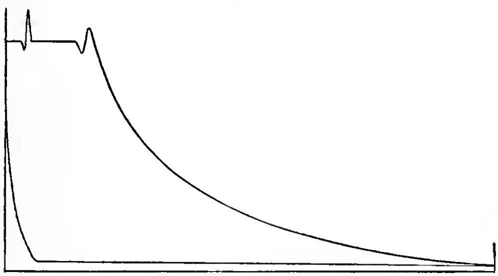


Fig. 2. Correct Diagrams

(Thompson type) was available, so pipes were led from the two cylinders to a three-way cock between the two cylinders. As the two cranks were at an angle other than 180 deg. to each other, it was necessary to attach a reducing rig to each crosshead. The two pantographs used, being direct-reducing rigs, caused both diagrams to fail

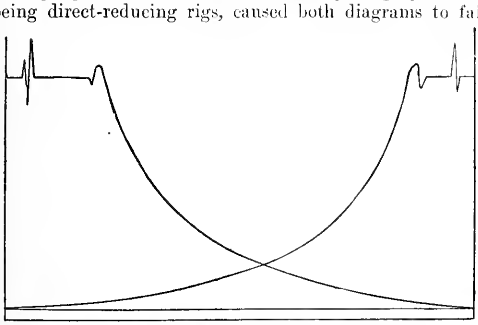


Fig. 3. Diagrams Incorrectly Taken

at the left end of the card, and made it desirable, if not necessary, to take them from the two cylinders on separate cards. Normal diagrams are shown in Figs. 1 and 2.

During the noon hour while I was away for lunch, the man operating the indicator did some investigating and devised a short cut to suit himself. Finding by experiment that one reducing rig, acting indirectly with respect to the one for the other cylinder, would put the two diagrams on opposite ends of the same card, and forgetting that the function of a reducing rig is to move the indicator drum in time with the piston to which it is attached, he discarded one pantograph and got the diagrams, Fig. 3.

When the pencil point wore down and the diagrams became faint, he unscrewed the handle from the pencil mechanism and jammed the point so hard against the drum that the pencil arm bent sufficiently to catch under the end of the front pedestal shaft and cut off the tops of the diagrams as shown in Fig. 4. No less than half

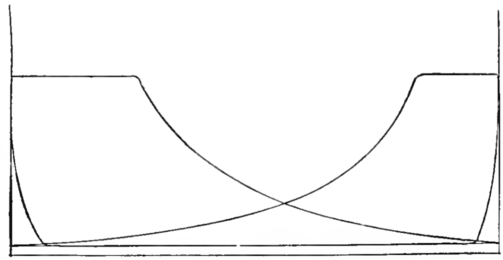


Fig. 4. Top of Diagrams Missing

a dozen such diagrams were taken and delivered to the man operating the planimeter, who integrated the areas and entered them on the log sheet without question.

F. V. Larkin.

So. Bethlehem, Penn.

Corliss Governor Compensator

The issue of Nov. 24, page 746, describes a device used to assist a flyball governor to maintain the speed of an engine within 1 per cent. from no load to a 25 per cent. overload. It is stated that one of these compensators has been in use for five years, giving good results, and that it should prove of value in rolling mills, sawmills, etc., where the variation in the load is great.

Judging from the illustration and the description, it is my opinion that it would be useless, if not a detriment, even on engines operating with a comparatively steady load.

Suppose the load should suddenly become greater; the reduction in the speed of the engine would cause the governor to drop for a longer cutoff, thus throwing the compensator out of level. This in turn would cause the mercury to shift to the lower end of the tube and by its weight hasten the downward movement of the governor. So far its work is admirable, but what would take place when the extra load goes off?

The governor tends to rise for a shorter cutoff and, in addition to lifting itself, is burdened with the extra weight of the mercury in the lower end of the compensator. This will require a higher speed of the governor and of the engine than if the device were not used.

When the extra load came on and the mercury took the lower end of the tube, the governor would not allow the engine to drop to as low a speed as if the mercury tube were not used. On the other hand, the governor would require a higher speed in order to raise the additional weight to a point where the tube would be level, or inclined the opposite way if necessary. What is gained one way is counteracted in the other, and should the fluctuations in load be great and frequent, the device might prove to be a detriment.

Another statement says the division walls prevent any sudden shifting of the mercury. It seems that to hold the speed within narrow limits the shifting should be sudden, and if the device provided for this in both directions, without the necessity of lifting it at the expense of the speed of the governor after it is once out of level, the results would approach the ideal.

I am inclined to think the description does not cover the ground; that something is omitted that would explain the apparent defect, because if it has been used for five years with good results, we have no right to dispute the statement.

The article also says "it has the same effect as automatically increasing or decreasing the weight of the balls," etc. This is true, but which way will the change in speed of the engine be for a given change in the governor balls? By test, the engine was found to run slower for an increase in the weight of the governor balls and *vice versa*, the dead weight or counterpoise weight remaining unchanged. Therefore, when the tube shifts for a longer cutoff it produces the same effect as if the balls were made lighter, and an opposite shift produces the same effect as if they were heavier.

Joseph Stewart.

Hamilton, Ohio.

Using Short Gage-Glasses

Among other things bought in a job lot were about four dozen gage-glasses of good quality but too short for any of our regular connections. I hit upon the following way of making use of them:

The upper packing nut was replaced by a reducing coupling, threaded to suit, into which a short brass pipe was screwed. The lower end of this pipe was threaded to receive a pipe cap, which had been bored out a neat fit over the gage-glass. This formed a good stuffing-box for lower pressure. It happened in this case that the bore of the pipe was just right for the glass, otherwise a washer at the end of the pipe would have been necessary, to form the bottom of the stuffing-box.

Short glasses may be utilized on low-pressure work by using a piece of hose to join the ends wherever they may come, thus forming a flexible joint. Long receiver-tank glasses will often last longer when in two parts than in one.

Arthur D. Palmer.

Dorchester, Mass.

Why the Old Engineer Lost His Job

Coming back to Boston after five years in South America, the first thing I did was to visit my old friend, Bill, the engineer. Long before I can remember—in fact, before I was born—he was there at the plant. I had thought many times of him, his big, smiling face, as he sat in a large wooden armchair in the engine-room doorway smoking his old pipe; and he always had a friendly word for us kids.

Arriving at the engine room, I was surprised not to see Bill in the doorway; even the chair was missing. The old engine had been displaced by a turbine, and at the desk was a stranger reading a blueprint.

I asked for Old Bill (I never did know his last name) and was told I would find him in the pipe shop. It made me feel good to hear that he was still at the plant and it did not take me long to cross the yard. The first man I met was Bill, but what a different man!

"Are you Bill, the engineer?"

"Yes—I used to be."

"Used to be; what's the trouble; why are you not now?"

"Well," said he, "the 'Old Man' died and his son took charge a couple of years ago, and that fixed me all right. He put in new machinery and then he wanted me to make tests on the boilers and turbine, and to send a monthly report of everything to the office. I didn't know how to do those things. They got a new engineer, but kept me around the plant, and there you are. Many a time I wish I was dead, as this come-down is awful."

The thought came to me right there, how many engineers of the old school will go the same way, because they don't know!

H. C. Harris.

Boston, Mass.

Corrosion of Iron and Steel Pipe

There are no reliable data as to the relative ability of iron and steel to resist corrosion. Furthermore, it is a difficult matter to identify the two materials without the acid-etching test. Some time ago, an engineer with many years' experience in the installation of steam and hot-water heating plants remarked that he could tell whether the pipe was iron or steel by the way a die cut. Some short pieces of pipe were submitted to him to separate the iron from the steel. His attempt met with such indifferent success, as shown by the acid test, that he remarked: "There's one thing certain, I don't know iron from steel."

Besides threading easier, he believed that iron pipe resisted corrosion better than steel. Both these beliefs were shaken when he learned that he could not distinguish between the two.

The popular notion is that if it corrodes easily, it is steel; if it offers considerable resistance to corrosion, it is iron.

Some years ago the purchasing agent for a packing house ordered from the mill a number of bars of strictly wrought iron. There was no wrought iron in the plant, everything being soft and medium steel. The manager had the order filled from the steel stock, saying: "If they discover the difference we'll refund their money and give them the steel." The manager had some misgivings until another order was received from the same agent for more iron. This is an incident of which I have personal knowledge.

Later, I was employed in two different packing houses and was amused by the stories of the wonderful durability of wrought iron and the utter worthlessness of steel under packing-house conditions. There is much difference of opinion among those who ought to know; one makes a test that proves conclusively that steel corrodes faster than iron; then another makes a test that proves the contrary. The only vital difference I have been able to find is in the price, steel being cheaper.

C. O. Sandstrom.

Kansas City, Mo.

Inquiries of General Interest

Conversion of Heat into Work during Expansion—Why should steam lose any of its heat when expanding and doing work, if it loses none while expanding and doing no work?

W. R. W.

Heat and energy are mutually interchangeable, and when work is done in the process of expansion it is performed not by loss but by conversion of some of the heat of the steam into energy, each heat unit thus transformed being converted into 778 foot-pounds of energy, and as a consequence of the transformation, the remaining heat in the steam must be less than the heat which it contained before doing the work.

Brake Power of Engine—What brake horsepower is developed by an engine when the length of brake arm is 60 in., tare weight of brake 20 lb., total pressure of brake arm 156 lb., and brake wheel makes 200 r.p.m.?

T. R.

The brake horsepower is given by the formula

$$\frac{\text{Length of brake arm in feet} \times 2\pi \times \text{net weight or pressure lb.} \times \text{r.p.m.}}{33{,}000}$$

hence there would be

$$\frac{\frac{60}{12} \times 2 \times 3.1416 \times (156 - 20) \times 200}{33{,}000} = 25.89 \text{ b.hp.}$$

Metering Fuel Gas at Different Pressures—What would be the relative weight of equal volumes of fuel gas measured by a volumetric meter at 8 oz. and at 12 oz. pressure?

R. V. S.

For the same temperature the density would be directly as the absolute pressure. Taking the pressure of the atmosphere at 14.7 lb., or 235.2 oz., per sq.in., and assuming the gas pressures are quoted in ounces per square inch in excess of atmospheric pressure, then for 8 oz. pressure the absolute pressure would be

$$235.2 + 8 = 243.2 \text{ oz.}$$

and for 12 oz. pressure it would be

$$235.2 + 12 = 247.2 \text{ oz. per sq.in.},$$

hence, a given volume metered at a pressure of 12 oz. would be $\frac{247.2}{243.2}$ as much or about 1.6 per cent. more than when metered at a pressure of 8 oz. above atmospheric pressure.

Weight of Plunger When Submerged—When submerged in water, what would be the weight of a hollow bronze pump plunger 18 in. in diameter by 70 in. long, having ends 4 in. thick and sides ¾ in. thick?

S. C.

The weight immersed will be the difference between the weight of the plunger in air and the weight of the volume of water displaced. The volume displaced would be $(18 \times 18 \times 0.7854) \times 70 = 17{,}812.9$ cu.in., and taking the weight of water as 0.0361 lb. per cu.in., the weight of water displaced would be $17{,}812.9 \times 0.0361 = 643.046$ lb. The hollow part of the plunger being a cylinder 16½ in. in diameter by 62 in. long, the net volume of metal would be

$$17{,}812.9 - [(16\tfrac{1}{2} \times 16\tfrac{1}{2} \times 0.7854) \times 62] = 4555.7 \text{ cu.in.}$$

and taking the weight of bronze as 0.3195 lb. per cu.in., the weight of the plunger in air would be

$$4555.7 \times 0.3195 = 1455.55 \text{ lb.}$$

so that the weight of the plunger submerged would be

$$1455.55 - 643.046 = 812.51 \text{ lb.}$$

Effect of Short-Circuit in Field Coils of Alternator—What would be the effect of a short-circuit in the field coils of an alternator?

W. C. R.

It would depend somewhat upon the windings and the way they are connected. If the machine is either one-, two- or three-phase there would be a decrease in the voltage. If the windings of the three-phase machine are delta connected there will be local current set up in them which may be so serious as to cause overloading that would affect the lights connected to the machine. One ground in the field, with the rest of the system insulated, would have no effect, but if combined with a ground on some other part of the circuit it would cut out one or more of the field coils.

Origin of "Horsepower"—What is the origin of the term horsepower?

R. C.

Before the introduction of steam engines, the work of horses was employed for driving mills, pumps and other machinery, and the power required for their operation was commonly expressed in the number of horses required, and numerous estimates were used for the average working power of a horse. For rating the power of their steam engines Boulton and Watt adopted an estimate based upon their observations of the power of strong draft horses employed 8 hr. per day at London breweries. They found that a horse was able to go at the rate of 2½ miles per hour and at the same time raise a weight of 150 lb. by means of a rope led over a pulley, and the rate of work performed, viz.,

$$\frac{2\tfrac{1}{2} \times 5280 \text{ ft.} \times 150 \text{ lb.}}{60} = 33{,}000 \text{ ft.-lb. per min.}$$

thus established as a horsepower, has been continued as the standard among English-speaking peoples.

Size of Common Exhaust Pipe—What is the rule for finding the diameter of a common exhaust pipe for engines having, respectively, 4-in., 6-in. and 7-in. exhaust connections without materially increasing the back pressure?

P. E. M.

The relative flow of steam of the same density in different pipes varies as

$$\sqrt{\frac{d^6}{d + 3.6}}$$

in which d = diameter in inches. Assuming that the exhaust is at the same pressure in each pipe at the point where they are joined together, then without materially altering the back pressure from what it would be from an equal extension of each exhaust pipe, the diameter of the common exhaust pipe would be the value of d in the equation

$$\sqrt{\frac{d^6}{d + 3.6}} = \sqrt{\frac{4^6}{4 + 3.6}} + \sqrt{\frac{6^6}{6 + 3.6}} + \sqrt{\frac{7^6}{7 + 3.6}} = 198.27$$

By assigning different values to d the nearest even pipe size required is found to be between 9 and 10 in. and therefore a common exhaust pipe of 10 in. diameter should be employed.

Capacity of Closed Water Heater—What quantity of water can be heated from 60 deg. F. to 180 deg. F. by a sufficient supply of exhaust steam at 4-lb. gage pressure in a closed heater containing 21 three-inch iron U-tubes having an average length of 16 ft.?

P. B. B.

Standard 3-in. iron lap-welded boiler tubes have an internal diameter of 2.782 in., and the heating surface would amount to

$$\frac{2.782}{12} \times 3.1416 \times 16 \times 21 = 244.72 \text{ sq.ft.}$$

Taking the average temperature of the steam as 218 deg. F., and average temperature of the water as 120 deg. F., the average temperature difference would be 98 deg. F., for which there would be a condensation of about 18 lb. of steam per square foot of pipe surface per hour, and as each pound of steam would liberate about 966 B.t.u., the total heat transmitted to the water would amount to

$$966 \times 18 \times 244.72 = 4{,}255{,}191 \text{ B.t.u. per hr.}$$

and as each pound of water raised from 60 to 180 deg. F. would require

$$180 - 60 = 120 \text{ B.t.u.}$$

there would be

$$4{,}255{,}191 \div 120 = 35{,}459.9 \text{ lb.}$$

or about

$$35{,}456 \div 8.33 = 4256 \text{ gal. of water heated per hour.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Hearing on Massachusetts Licensing Bill

Several hundred engineers and firemen attended a hearing at Boston, Mass., on Mar. 10, given by the legislative committee on mercantile affairs upon House Bill 1111, a measure introduced by various interests to render the licensing of engineers and firemen easier than under the present law. The hearing was one of the most hotly contested of the session, operating engineers from all parts of the state registering their opposition to the proposed changes in the law.

ABSTRACT OF THE BILL

The bill provides that to be eligible to apply for examination for a fireman's license, a person must have been employed as a fireman for not less than one year. The examination must be of a practical character, to ascertain whether the applicant has thorough knowledge of the functions of a steam boiler and its appurtenances, of the proper methods of operation and cleaning, how to proceed in case of accident, low water, or in the event of signs of distress; of packing handholes, manholes, valve stems and pipe flanges, and of the proper condition and management of boilers and their accessories, including pumps and other feeding devices.

Steam engineers' licenses are required by the bill in the operation of all engines of 25 hp. and over, with the usual exceptions of railroad locomotives, agricultural engines, etc., instead of the 9-hp. limitation of the present law. Thirty days are allowed for evidence of a second violation, in place of one week as at present. To be eligible for a first-class engineer's license, a person must have held a second-class license or must have been in charge of an engine or engines of over 150-hp. rating each, for a period of not less than two years, or must have served as a steam-engine erector, mechanical engineer or master mechanic of a plant having an engine or engines of over 150 hp. rating each, for not less than three years. The examination for a first-class engineer's license is required to be of a practical character to show whether the applicant has thorough knowledge of the construction, proper care and safe operation of steam engines and their appurtenances.

A second-class engineer's license entitles a steam engineer to have charge of any steam engine or engines not exceeding 150 hp. each, under charge of a first-class licensed engineer. To be eligible for a second-class license, a person must have operated a steam engine or engines for not less than one year, or must have served as a steam-engine erector, mechanical engineer or as master mechanic for not less than two years. The examination covers about the same range of topics as for a first-class license with the exception that knowledge of engine construction is not required. A person seeking a third-class engineer's license may take an examination upon presentation of a request signed by the engine owner or user, such license entitling the holder to operate a particular engine or engines without limit as to size. In other particulars the bill generally follows the existing law. It provides for the retention of all existing licenses and for their exchange, when desired, for licenses under the new law, according to a tabulation which need not be reproduced at this time.

Edward P. Butts, chief engineer of the American Writing Paper Co., Holyoke, the original petitioner for the bill, was the first speaker. He pointed out that under the present law engines and boilers are held to be equal as hazards. He contended that the boiler presents the greater risk, indicated by the fact that most boilers are insured against accident, but comparatively few engines. Constant attendance, he held, is essential in the boiler room, but not at the engine. The present law is complex, in his opinion, and the petitioners object strenuously to the lack of uniformity in examinations for licenses. The character of the examinations depends too much upon the discretion of local inspectors and is frequently too technical. Mr. Butts contended that firemen should not be examined on points in boiler construction nor engineers on details of engine design, claiming that the examiners should ascertain merely whether a man is competent to run the equipment without any extended theoretical knowledge of it. He held it to be unfair to owners of plants using water power a large part of the year to require them to hire skilled engineers for twelve months, when steam-auxiliary service may be needed only for two or three. Another point which the bill is designed to care for is the elimination of the first-class engineer as a necessity to the operation of portable engines. Connecticut has no such license law as Massachusetts, and the speaker contended that the operation of engines and boilers is just as safe there as in the Bay State.

William McCorkindale, Holyoke, representing the Parsons Paper Co., attacked the questions given candidates for a second-class engineer's license on the ground that they are too technical. In a specific instance one candidate failed through inability to tell the examiners the physical properties of steam, the ratio of expansion in turbine blades, and why a fusible plug melts when low water occurs in a boiler.

C. A. Crocker, Chemical Paper Manufacturing Co., Holyoke, said that too much discretion in the enforcement of the existing law is placed upon the inspectors in local districts. He felt that the bill provides as well for safety as the existing law and pointed out that a man to have charge of a large plant should not necessarily have a fireman's license.

James O'Brien, Lee Marble Works, Lee, said that the present law requires his concern to put a steam engineer on each channeling machine because the engine is rated at 12 hp. This, he said, has been a great embarrassment, because specially trained men are required to operate channelers in quarries. Under the present law he could not even utilize the services of the manufacturer's erectors in the operation of channelers. He cited the case of an experienced erector employed by the Sullivan Machinery Co., Claremont, N. H., to instruct Russians and other purchasers in the use of channelers made by this company. This erector could not obtain a Massachusetts license because he was unable to answer purely technical questions about steam engineering. The present law limits engines to 9 hp. without a licensed engineer, and the speaker urged that a 25-hp. limit be adopted. He said that at present a man with a third-class license could run a single engine not exceeding 50 hp. in rating, but if such a machine broke down and the employer wanted to run two 10-hp. engines or two 25-hp. engines by the same man, there would be a violation of the statute.

Mr. O'Brien said that these restrictions made it much harder for Massachusetts companies to compete with concerns in other states and led indirectly to the employment of fewer engineers than would be the case under the proposed law. Thus, in Georgia, no license is required to operate quarry machines by steam, and there is no law in Vermont which licenses engineers and firemen. He thought that in these industrial plants special licenses should be given in many cases. He said that in the paper industry conditions are fully as troublesome through the present law, which may force electrification of many mills if operators of paper machines are not allowed to start and stop their steam-driven apparatus without the immediate supervision of licensed engineers. The ruling of an inspector now on duty in the Connecticut Valley, that a certain mill should employ a steam engineer for each paper machine, threatens to increase the payroll by $300 per week.

George P. Gilmore, an engineer with the American Printing Co., Fall River, brought out the point that the number of engineers' licenses issued has fallen from 97 first-class in 1911 to 62 in 1913, and from 186 second-class to 115. He stated that there are 1726 first-class licenses outstanding in Massachusetts today and 1796 second-class. At the present rate of increase it will take twenty-eight years to replace the present number of first-class engineers and eighteen years to replace the second-class men. He objected vigorously to the absence of any appeal from the decisions of the examining board.

Capt. White, Lowell Paper Tube Corporation, Lowell, contended that the law should specifically limit the powers and scope of examiners. Requirements for licenses should be definite, as in the Navy, where the speaker had spent 36 years. The naval examination of firemen is always oral and purely practical. Capt. White bewailed the fact that a man can fire a torpedo-boat boiler and still be unable to get a fireman's license for a Massachusetts stationary plant.

Frank Dresser, American Steel & Wire Co., Worcester, pointed out that in his opinion the bill does not impair safety. The United States Steel Corporation does not consider the holder of an engineer's or fireman's license as necessarily qualified for plant operation. The company desires to know what sort of an examination was given and does not favor the present non-standardized methods. Knowledge of stresses in steel is unessential to the proper handling of power plants, the speaker contended. The company at present employs 125 engineers and firemen at Worcester, and in normal business periods 200.

Frederick M. Ives, for the Massachusetts Electric Lighting Association, Boston, also favored the bill.

Clifford Anderson, for the Norton Co., Worcester, said that one of the best engineers in the state operates a 250-hp. steam engine, a 500-hp. gas engine, and a 1000-hp. steam turbine in the company's plant, on a special license. This engineer, who has maintained the engine service for twelve years without a minute's loss of time, who has run the gas engine with a loss of only 0.5 per cent. in working time, and who has run the turbine unit one year and three months without a moment's stoppage due to machinery trouble, cannot get a first-class license in any other plant because of his inability to answer highly technical questions put by the examiners. The speaker attacked the present law on the grounds that it keeps out competent men, and he criticized examinations upon theoretical points.

Samuel M. Green, Springfield, Mass., consulting engineer, appeared on behalf of the Springfield Board of Trade and a large number of paper and other manufacturers in the Connecticut Valley. He said that his clients do not consider that the Massachusetts license is an index of a man's ability to operate a given plant and that often the examinations contain foolish questions. The bill stipulates that the examination of both engineers and firemen shall be of a distinctly practical nature. Mr. Green stated that the American Society of Mechanical Engineers has been considering a standard set of regulations governing the licensing of engineers and firemen, but that it had withdrawn the plan of closely following the Massachusetts law in this respect. The speaker contended that there are numerous inconsistencies in the present law which work hardships to the plant owner. Thus, the law now holds that an engine of over 50 hp. must be operated by a man with a second-class license. By reducing the speed of a 60-hp. engine on a paper machine 15 per cent., for example, its rating may be cut down so that it can be run by a third-class engineer. In one plant the owner employed a technical graduate as plant engineer. He was refused a license because he had not fired a boiler for a year. At the Hotel Kimball, Springfield, an engineer from New York State was refused opportunity to take the Massachusetts examination because he had not resided in the latter state for from four to six weeks. Mr. Green contended that firing is not an essential preliminary to an engineer's job.

OPPOSITION TO THE BILL

A. M. Huddell, Boston, who said he represented 13,000 men affiliated with the Massachusetts branch of the International Union of Steam and Operating Engineers, maintained that the bill jeopardizes public safety and contended that while uniform examinations and uniform enforcement of the present law are desirable, the present bill should not be substituted. If the bill passes, third-class plants will be legislated out of existence. Mr. Huddell attacked the provision of the bill allowing thirty days to pass instead of the present seven after an inspector has found a plant improperly manned, before a violation can be charged. He said that an inspector ought to be permitted to enter a plant at any hour rather than at a so called "reasonable" hour, as stated in the bill. Manufacturers can get all the relief they desire from the present law if it is properly enforced. The speaker advocated the establishment of a mechanical department separate from the District Police, who now enforce the boiler and engine laws of the state.

D. G. Kimball, Roxbury, Mass., representing the National Association of Stationary Engineers, said that the entire plant should be in charge of the chief engineer, whereas the bill tends to divide the responsibility of the plant between the engineer and the fireman. He protested vigorously against lowering the standard of the examination and set forth the importance of an engineer's acquiring a broad knowledge of his profession, including both theory and practice. "Our aim," said Mr. Kimball, "is to enable an engineer to rise higher in his work. He should study and keep up with his trade, and we favor the present law because it tends to that end."

C. C. Harris, Springfield, Mass., president of the Brotherhood of Power Workers, held that it is unsafe to place a man in charge of a steam plant unless he knows something of the construction of engines. He cited instances of accidents to paper-mill steam-driven machinery through the mishandling of the equipment by unlicensed men. Failure to drain the pipes in one case cost two lives, through an explosion which followed suddenly turning on steam.

Thomas Hawley, head of the Hawley School of Engineering, Boston, was a vigorous opponent of the bill. Mr. Hawley said that the present law had served well for over twenty years; that it had led to great improvements in the handling of plants and had enormously diminished the number of explosions, besides raising the caliber of engineers and firemen. The proposed measure does not provide any really easier examinations and is a step in the wrong direction. The speaker ridiculed the inconsistency of the bill in requiring a man to work a year as a fireman before getting a fireman's license. The present law permits a man to start in as a helper. A way must be provided by which a man can enter the business.

The speaker pointed out that the present examinations are practical. Thousands of firemen have been examined on the operation of boilers and not on their responsible care. Under the terms of the bill a man practically unqualified could be put in control of equipment on which he has not been examined. The examinations are not unduly difficult. The speaker favored requiring that the applicant be able to understand the English language before a license be granted. In the Slater Mills, at Webster, Mass., a disastrous explosion occurred because a fireman who did not understand English closed a stop valve instead of opening another valve, as ordered. "Trick" questions are not used in the examinations. Mr. Hawley said that the bill is unnecessary; that a line must be drawn somewhere in establishing the limits of engine size for a new class of license, and pointed out that just above and below such a line there is always room for complaint. He condemned as particularly dangerous the section of the bill providing that a third-class license can be issued to enable a man to operate any particular steam-engine plant, there being no limit on size here. A man has to get a job before he can get a third-class license, under the bill. Special licenses are troublesome and should be discouraged. Mr. Hawley brought out the point that familiarity with marine engines and boilers by no means fitted a man to run stationary plants. Torpedo-boat equipment, for example, is different from that of a factory or central-station plant. In one case a navy fireman knew nothing about the location of the fusible plug in a stationary boiler.

T. N. Kelly, Lowell, Mass., criticized the division of responsibility between the fireman and the engineer and said that under the present law an extra first-class fireman's license provides for correcting local differences due to water-power service a part of the year. H. M. Comerford, Boston, took the same ground.

Capt. George Dimand, Lawrence, Mass., opposed the bill on the ground that it would work hardship to both employer and employee. Division of authority between engine room and fire room is most undesirable. The bill would allow any fireman after running one year to take charge of any boiler plant. This is an insufficient time for a man to grasp the operation of the plant as a whole.

The bill was also opposed by Elmer Stevens, Cambridge, Mass., representing the New England Power League. He contended that the personnel of engineers in Massachusetts has improved under the existing law, emphasized the fairness of the present law, and touched upon the certainty of a square deal in examinations. The committee reserved its decision.

The Computation of a Rate

At the recent convention of the Indiana Engineering Society H. O. Garman, chief engineer of the Public Service Commission of Indiana, discussed a simple method of computing a rate, which was thought fair and reasonable to the different classes of consumers and would give a reasonable return to the investor. As expressed by Mr. Garman, the difficulty now with a great many rates placed on file with the commission by the utilities is that they are too complicated for the ordinary consumer to understand. In many cases the latter, in trying to choose, for instance, an electric rate, is compelled to give up in despair and seek the advice of an expert in selecting a rate that will be economical. The ordinary user is completely lost when he comes in contact with such terms as "load factor," "connected load," "maximum demand," "assessed demand," "measured demand," "off-peak load," "fixed charges," readiness-to-serve charge," "energy charge," etc. The tendency now is toward a simplified rate schedule which can be more nearly understood by the ordinary consumer.

The rate evils, as they have been discovered in Indiana, are not so much rates that are unreasonably high as they are rates that are grossly discriminatory. The unjust discriminations have been brought about by competitive conditions and by lack of publicity.

The failure of the general public to realize that there is a "readiness-to-serve charge" gives rise to a great deal of dissatisfaction. When they can be educated to understand that there is such a charge, they see why it is necessary to charge the small consumer at an apparently higher rate than the larger one. The former feels that he is being persecuted because he is a helpless small consumer, when, in fact, in many cases it would not be possible to furnish him service at all at a rate within his reach were it not for the large user.

Those officers of the public upon whose shoulders falls the duty of fixing these rates are becoming convinced that more simplicity is needed. It works out better to have rates that are less scientific, so called, and more easily understood by the greater number of consumers; and after all, the utility is not so much interested in a scientific rate as it is in the gross return that a rate will bring. In other words, what seems to be needed most in rate schedules is less scientific obscurity, a reasonable gross income to the utility and more simplicity and uniformity for the consumers.

Every correct rate should take into account three elements of cost to the utility: Readiness-to-serve cost, energy cost, and customer's cost. Some of the elements of cost entering into readiness-to-serve cost are: Interest return on agreed valuation, rentals, part of allowance for obsolescence, taxes, insurance, and part of the operating costs. The energy cost is made up principally of the so called operating costs, while the customer's cost is made up of items that are directly traceable to the customer, such as reading meter, billing, collecting, testing meter, and the like.

To make the rate matter clearer to the ordinary consumer, an example will be taken by way of illustration. Assume, for instance, three classes of consumers of electricity—power, stores and residences. Assume the cost per kilowatt of demand per month to be $1.20, $3.40 and $4.60, respectively. Assume the energy cost to be $0.01 per kilowatt-hour and the customer's cost per month to be $0.40. Then a table can be computed showing the varying cost per kilowatt-hour, as the hours' use of the demand varies from 15 min. to 24 hr. in one day.

VARYING COST PER KILOWATT-HOUR AS TIME OF USING DEMAND VARIES

Hr. Use of Demand in 24 Hr.	Cost per Kw.-hr, Power	Stores	Residences
0.25	$0.223	$0.517	$0.677
0.50	0.117	0.266	0.346
1.00	0.063	0.137	0.177
1.50	0.046	0.094	0.121
2.00	0.037	0.073	0.093
3.00	0.028	0.052	0.066
4.00	0.023	0.042	0.052
5.00	0.021	0.035	0.043
6.00	0.019	0.031	0.038
7.00	0.018	0.028	0.034
8.00	0.017	0.026	0.031
9.00	0.016	0.024	0.029
10.00	0.015	0.023	0.027
11.00	0.015	0.022	0.025
12.00	0.014	0.021	0.024
24.00	0.012	0.015	0.017

Mr. Garman was well aware that there were many conditions and kinds of service which would seem to justify a multitude of rates, all of which might stand the test of fairness and reasonableness, but in the practical administration of a rate schedule it seemed best to take advantage of averages and work toward simplicity of schedule.

Heating Boiler Bursts

A heating boiler being installed in the new Country Club building by the C. C. Hartwell Steam Fitting Co. burst Mar. 3 on being tested, according to a New Orleans (La.) correspondent. Robert Snow, in charge of the job, was badly scalded, though he may recover. That he was so seriously injured was thought to be due to his heroism in forcing his way to the cutoff valve so as to shut off the steam. But for this action it is considered likely that Ernest Keppler, a helper, who sprained his ankle in trying to get away from the danger, would have been scalded to death. Joseph Martinez and William L. Purduit, also employed on the installation, sustained burns of the face and hands.

Snow and his helpers had just completed the erection of the boiler, and in making a test the pressure had been raised quickly to capacity. It was stated that the workmen, relying on a larger factor of safety than seems to have existed, raised the pressure past capacity for the sake of a thorough test.

BUSINESS ITEMS

The E. Keeler Co. of Williamsport, Penn., has been awarded a contract for 18 water tube boilers by the Illinois State Board of Control. Nine of these are 300 hp. and nine 400 hp., with automatic stokers.

The Buffalo Forge Co., Buffalo, N. Y., is sending out a new catalog (No. 201) on Niagara Conoidal Fans. It contains many illustrations of actual installations, complete tables for capacities, speeds and horsepowers for all sizes of fans, as well as dimensions and characteristic curves. Copies are sent to consulting engineers, manufacturers, architects, etc., on request.

The Yarnall-Waring Co., Chestnut Hill, Philadelphia, has just received orders for four "Lea" V-notch recording liquid meters in combination with Webster feed water heaters aggregating 1,125,000 lb. per hour capacity, from E. I. duPont DeNemours Powder Co., Wilmington, Del., following original installation of "Lea" system by them two years ago. Also an order for a 275,000 lb. per hour capacity "Lea" V-notch recording liquid meter for the new power plant of the Victor Talking Machine Co., Camden, N. J., following the installation of a 150,000 lb. per hour "Lea" instrument by them two years ago.

OBITUARY

WILLIAM H. ARMSTRONG

William H. Armstrong, Grand Worthy Chief of the Universal Craftsmen Council of Engineers of the World, died Mar. 16, at St. Rose's Hospital, New York City. He was one of the best known operating chiefs in the engineering profession, in both land and marine service. He was for many years chief engineer of the Rogers Peet Co. Building at Broadway and Warren St.

Mr. Armstrong was an active member of a number of engineering organizations, including Elmer E. Chambers Council, No. 5, U. C. C. of E.; Stephenson Association, N. A. S. E., and the United Engineers of Greater New York. He was Past Master of Ocean Lodge, No. 156, F. & A. M.

PERSONALS

W. H. Hoyt, C. E. 1890, College of Engineering, University of Minnesota, member of the American Society of Civil Engineers, assistant chief engineer of the Duluth, Missabe & Northern R.R., has been elected president of the Minnesota State Surveyors' and Engineers' Society.

Maj. A. B. Blevins, president of the North Louisiana Interurban & Electric Co., died from heart failure Mar. 4 at his home in Shreveport, La. He was the founder of the Town of New Birmingham, Tex., and one of the earliest developers of the iron-ore region of Texas. He went to Louisiana in 1912 and had been working ever since on the interurban line which is to connect Shreveport and Monroe, La.

ENGINEERING AFFAIRS

The American Boiler Manufacturers' Association has called a meeting of boiler manufacturers and others interested, to approve the code of uniform boiler specifications recently completed by the American Society of Mechanical Engineers. The meeting will be held at the Fort Pitt Hotel, Pittsburgh, Penn., Mar. 29, at 10 a.m.

Boston Engineers' Club announces the following program for the coming month: Thursday, Mar. 25, 1915, "Locomotives, Ancient and Modern," illustrated talk by George W. Stetson; Thursday, Apr. 1, 1915, Franklin A. Snow will describe some of his contracting experiences in South America; Thursday, Apr. 8, 1915, "Butte, Montana," an illustrated talk on modern mine development and operation, by George A. Packard; Thursday, Apr. 15, 1915, "Trees in Spring," illustrated talk by George Winthrop Lee; Thursday, Apr. 22, 1915, "Autogenous Welding and Cutting by Means of the Oxy-Acetylene Torch," illustrated talk by Henry Cave.

University of Illinois Notes—Prof. C. R. Richards, of the department of mechanical engineering of the University of Illinois, has designed a hydraulic absorption dynamometer, several of which have been built in the college shops. One is to be connected to the new 60-hp. six-cylinder Peerless automobile engine in the mechanical engineering laboratory. The engineering experiment station is conducting tests of various building materials to determine their coefficients of heat transmission. The work is being done by L. C. Lichty, research fellow, under the direction of Prof. L. A. Harding, of the department of mechanical engineering. The results of the tests are expected to be of especial value to heating and ventilating engineers. Apparatus for testing steam nozzles has just been installed in the mechanical engineering laboratory. Prof. O. A. Leutwiler and Messrs. H. W. Waterfall and A. B. Domonoske, of the department of mechanical engineering, are conducting an interesting series of tests on a friction clutch for the purpose of determining the relative value of different commercial materials used for clutch linings.

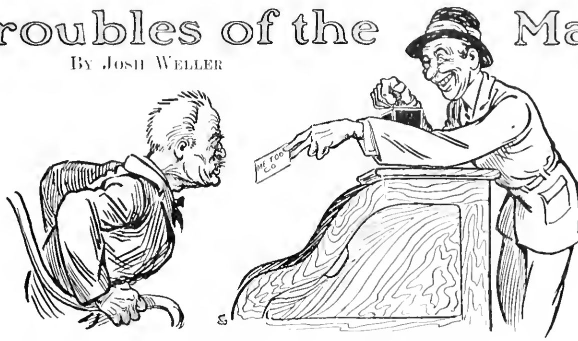
Accidents Due to Poor Lighting—That fully 25 per cent. of the accidents to workmen are caused by insufficient lighting for men working at night, is the opinion of experts who have made a study of the subject. It is estimated that $250,000,000 is the average annual cost of injuries to workmen in the United States alone, and that over 50 per cent. of these accidents are preventable.—"Popular Mechanics."

POWER

Vol. 41 NEW YORK, MARCH 30, 1915 No. 13

Troubles of the Manager

By Josh Weller



THE salesmen "lay" for me at night, they wait for me at morn;
I know they will be on my trail when Gabriel blows his horn.
They take my time when I should work, they do not seem to care;
I have no chance to change my pants, no time to pray or swear.
Oh, Holy Moses, Holy Smoke and Holy Mack'rel, too,
Look down at once and tell me quick, what can I, should I, do?

I BOUGHT a monster bulldog once, with teeth like Teddy R.;
I tied him at my office door and left that door ajar.
I chuckled low, I chuckled long, and then I chuckled some;
I said, "We'll see some royal sport when those fresh salesmen come."
They came at last, they came in force, that bloody salesmen gang;
They had a dentist with them, and he pulled each blooming fang.

I BOUGHT a pound of strychnine once and put it on some meat,
The rascals sniffed and smelled of it; they were too wise to eat.
I nearly killed a salesman once, a sassy red-haired runt,
He talked of testing furnace gas or some such crazy stunt.
I broke his neck, I broke his back, I broke his head and slats;
I threw him on a garbage pile to feed the dogs and rats.

NEXT morning when I came down town my eyes popped from my head,
The salesman on the garbage pile had risen from the dead.
He stayed and talked and talked and stayed and used up all my day;
At last I bought his worthless junk, there was no other way.
I sat before my fire one night to warm my frosted foot,
A salesman cuss came down the flue and filled the house with soot.

HE talked of scale and soot and ash and said my tubes were bad,
My heating surface punk, or worse. He sold me all he had.
Then when I got my nightie on, my "Now I lay me" said,
I found another salesman hiding underneath my bed.
There is no joy in life for me, no rest where'er I go,
Some salesman's always butting in, this world's a vale of woe.

AND when at last I shuffle off and hike for Peter's gate,
I'll find some salesman waiting for me there as sure as fate.
And if I give the scamp the slip and get inside the wall,
He'll steal St. Peter's golden keys and catch me after all.
Ha, ha, ha, ha, ho, ho, ho, ho, and likewise hee, hee, hee,
At last I know what I shall do, just watch my smoke and see.

I'LL buy a ticket right straight through to Satan's warm domain;
The bunch will all be after me, they'll all be on my train.
I'll bribe the Devil and his imps, I'll bribe them till I'm broke,
But I'll get those salesmen in the pit and pile on lots of coke.
And when one tries to scramble out he'll find me standing by,
Armed with a red-hot pitchfork, and I'll jab him in the eye.

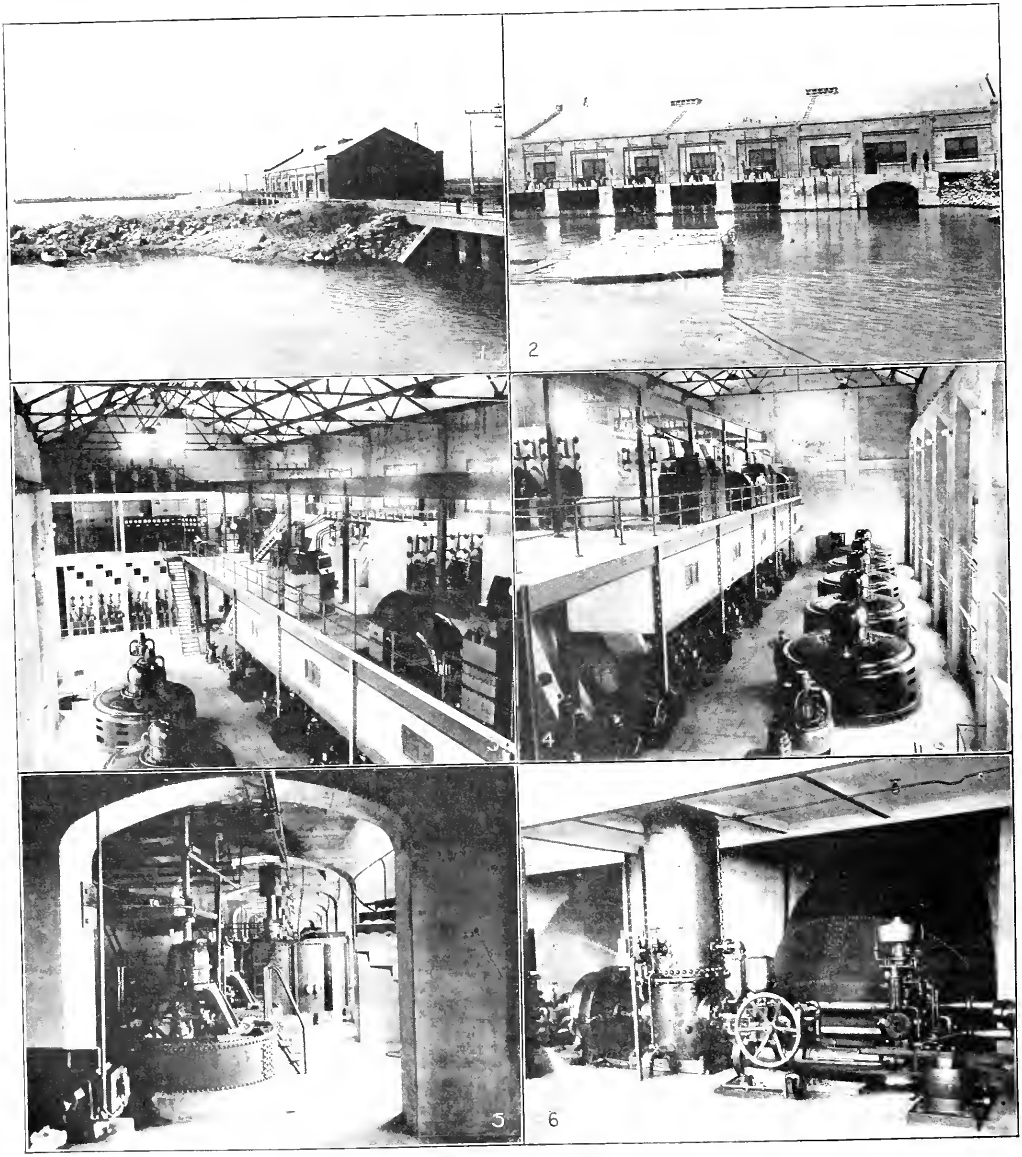
Read the Above to the Next Salesman That Calls on You

Federal Project at Minidoka, Idaho

By A. P. Connor

SYNOPSIS—The Minidoka project of irrigation consists of the Snake River dam to impound the water which supplies two main canals and which is also used to operate five 1200-kw. turbo-generator units at the power house. The current generated is transmitted to four pumping stations at distances of from twelve to twenty miles from the power plant, elevating the water from the main canal into canals at a higher elevation. The pumps have a capacity of about 125 sec.-ft. each.

The Minidoka project, situated in the counties of Lincoln and Cassica, Idaho, is typical of some of the Federal



Figs. 1-6. Views of the Minidoka Power Plant

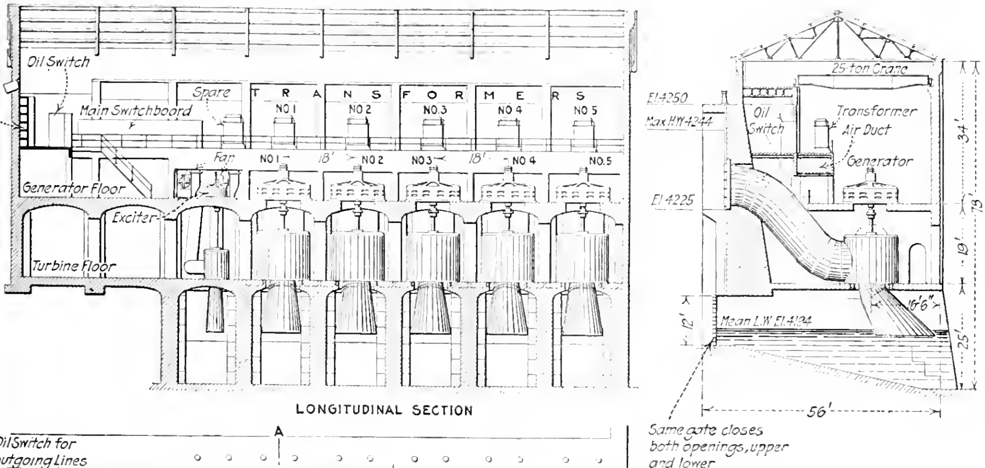
Government's undertakings requiring power for operation. In this case a storage dam 1300 ft. long impounds the water of an 18,000-square mile watershed and is supplemented by diversion dams 600 ft. long. The dams are of the earth- and rock-fill type, having an average height of 50 to 52 ft., and raise the water level sufficiently to supply two systems of canals having an aggregate length of 130 miles, and supplying 190 miles of smaller canals.

In addition, power is taken from the impounded waters hydro-electrically and transmitted to pumping stations at the terminals of these main canals where the water is pumped to higher levels for distribution to branch canals. At present about 6000 kw. is generated. This power is to supply water to 70 miles of main and 60 miles of branch canals by means of pumping stations located at distances of from 12 to 20 miles from the dam. The water is stored in Lakes Jackson and Walcott, and the average run-off is about 7,200,000 acre-feet. The altitude of the project is 4200 ft. above sea level. The hydro-electric generating units work under an average head of 35 ft.

In Fig. 1 is shown the main-dam, power house and the high-tension transmission line, looking from Lake Walcott. The power house is built of concrete and is a part of the dam; its general appearance from the intake side is shown in Fig. 2. Interior views are shown in Figs. 3, 4, 5 and 6. The maximum inside width of the building is 45 ft., and the usable width for the generators is about 20 ft., requiring a somewhat contracted arrangement of the units and apparatus.

The sub-basement of the power house is in reality a tunnel space for the passage of water through the dam whenever the lower gates of the dam are opened. The basement provides for the hydraulic portion of the plant, such as the penstocks, turbines and incidental casings. On the main floor are the generators, auxiliary apparatus and accessories. The gallery is for the switchboard, transformers, high-tension switches and the like.

The main transformers are in the power station and step up the voltage of the generators from 2300 to 33,000 volts, the connections being delta on the low-tension side and Y or star on the high-tension side. A spare transformer is provided for emergencies. The transformers



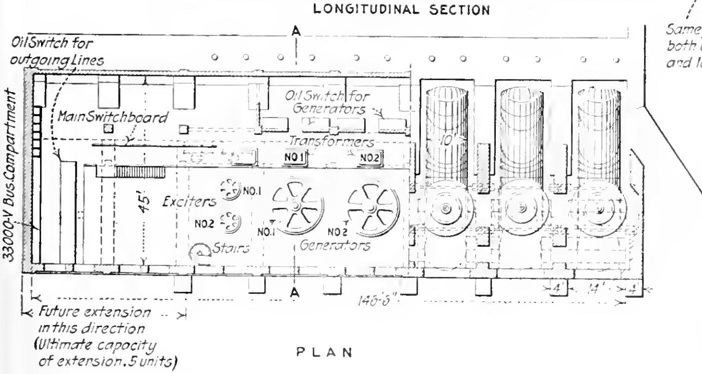


FIG. 7. SHOWING THE ARRANGEMENT OF THE POWER-PLANT APPARATUS

are air-cooled by means of motor-driven fans. The air duct for the same is suspended from the gallery and is shown in Figs. 3 and 4 above the control apparatus for the generating sets, etc.

GENERATORS

The vertical-type, revolving-field generators at present installed consist of five 1200-kw., 2300-volt, three-phase, 60-cycle and two small direct-current generator exciter sets which also run the station motors. The rated capacity of each alternator is 1400 kv.-a. at 85 per cent. power factor at a speed of 400 r.p.m. The generators are arranged on the main floor and connected with their turbines by extended shafts. The 120-kw. exciters are compound-wound, for 125 volts at 125 r.p.m.

TURBINES

The 1800-hp. main turbines are of the inward-flow, axial-discharge, single-runner type fitted with pivot gates. Those for the exciters are 180-hp. All of the turbines are between the arched columns in the basement, and ladders and passageways enable every part to be reached easily for inspection or repair.

The turbines are arranged for low head and are supplied with penstocks 10 ft. in diameter directed toward the turbines at a 45-deg. angle, with curved ends to reduce friction. Fig. 6 is a view of the governing apparatus. The penstocks are practically self-supported and are uncovered. The larger ones are closed by gates weighing 5 tons each, and operated by 6-hp. motors which receive energy from the 125-volt, direct-current busses. The gates for the exciter turbines are operated by a 2-hp. motor. The mechanism of the gates is outside the power station over the gates and is inclosed. The gates are arranged to close the upper and lower outlets in the dam so that when the upper one connecting with the penstock is open the lower one opening through the dam will be closed, and when the latter is open the former will be closed. This enables each gate to do double duty and avoids the need of two sets. They may be operated by hand when desired.

The draft tube of each turbine is enlarged at the end to improve the discharge. The penstocks and draft tubes are made of boiler iron in riveted sections. The station is provided with a 25-ton traveling crane for handling heavy pieces.

General

There are two main canals running from the dam, known as the Main North-Side Canal and the Main South-Side Canal, and these are filled with water by gravity. The latter is about 15 miles long and terminates adjacent to canals known as G, H and J, which are situated on higher levels. A transmission line is run 12 miles across the country from the power station to these canals to feed the motors at the pump houses. The pumping station No. 1 takes the water from the Main South-Side Canal and raises it to the level of Canal G, which is about 20 miles long. About a mile distant water is taken from Canal G and raised to Canal H through No. 2 pumping station. Canal H is about 25 miles long, and Canal J is fed with water from H through another station, No. 3. Pumping station No. 4 is on a transmission line on the north side of Snake River and takes water from the North-Side Canal. This station is about 20 miles from the dam, by air line, and about 30 miles by following the transmission lines. These are shown in Fig. 8. The layout of the system is such that the transmission lines are tied in and are run to include the various towns on the project. The main object of the power is, however, the pumping.

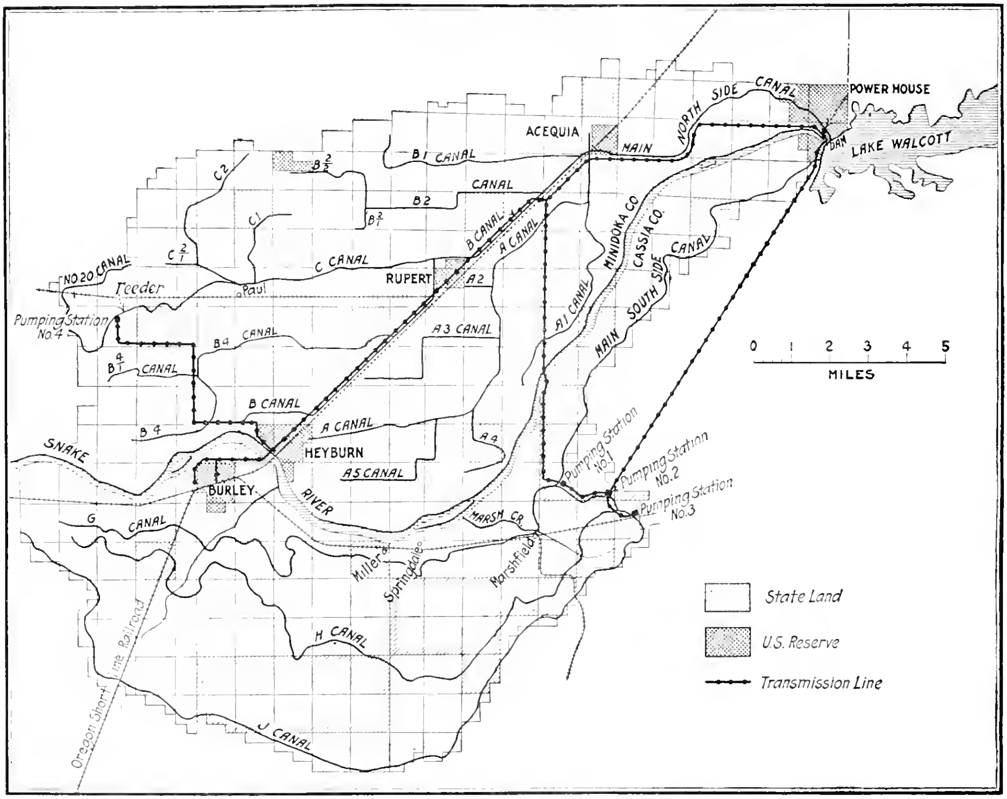


Fig. 8. Map of the Minidoka Project, Showing the Area, Its Canals and Transmission Lines

The pumping stations are buildings of substantial dimensions and are equipped with ample pumping units for the duty expected at each location. Each station has air-cooled step-down transformers. Exciter and motor-generator sets are provided for the minor direct current required for small motors and lighting in the pumping stations.

The ultimate capacity of the pumping stations in pumping units is as follows: No. 1, four pumping units, each of 125 sec.-ft. capacity; No. 2, three pumping units, each of 124 sec.-ft. capacity; No. 3, one pumping unit of 125 sec.-ft. capacity; No. 4 is about the size of that for No. 3.

Details of a pumping unit are shown in Fig. 9. It is driven by a 2200-volt synchronous, three-phase, vertical motor. The pumps are of the centrifugal type, taking the water centrally and forcing it out peripherally. The pumps are arranged to be always submerged, and the amount of water supplied and raised by each is controlled by gates with lips, which close the ingress openings to the pumps. The gates in each case are operated through a lever mechanism actuated by a float disposed in the incoming water, Fig. 9.

A baffle plate is provided above the entrance of each pump to keep out obstructions and to serve as a guide for the lip-operating rods. A grating in front of the water

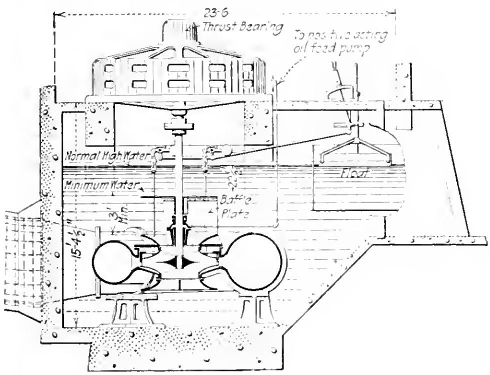


Fig. 9. Vertical Section of a Pumping Unit

entrance of each pumping station keeps out general rubbish and ice. The float mechanism has a lever and rack for raising it independently of the water.

The water raised by the pumps is diverted through an upwardly curved pipe or duct, from which it goes to its respective canal.

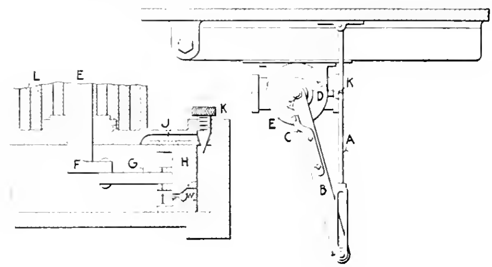
Morrow Furnace System

The Morrow system is an automatic furnace door-closing device to assist combustion, to obtain the maximum amount of heat from the fuel and to eliminate smoke. The equipment consists of a check with a supplementary device for holding the door of a furnace wide open while the fireman is putting in the fuel, and which on the release of the catch allows the door to swing to a closed position, hesitating long enough when partly closed to allow an inrush of the required amount of air necessary for combustion.

The checks are mounted upon the furnace door and are operatively connected by the links *A* (see illustration), with the boiler front. *B* is the operating arm, which is connected to the link *A* at one end and to the retarding mechanism at the other. *C* is a spring detent, which, when the furnace door is open, will engage within the notch *D*, formed in the upper surface of the casing of the device, so as to retain the door in an open position. In the sectional view through the closing device, the vertical shaft *E*, operated by the arm *B*, is provided with a crank *F* at its lower end, which is connected to the link *G* with the piston *H*. A check valve *I* opens to admit the retarding fluid when the furnace door is opened, but prevents the fluid from passing through the piston, when the piston moves in a direction to close the door.

The bypass *J* extending around the piston is controlled by the needle valve *K*, by the adjustment of which the flow of liquid is governed through the bypass, which regulates the speed at which the door will close.

When the furnace door is opened it moves the upper end of the casing of the closing device relatively to the spring detent *C*, until the latter engages within the notch *D*, thereby holding the door open. After firing, the door is given a slight push inwardly, which unseats the detent



Details of the Morrow Furnace System

C and permits the spring *L* to close the door. The operation of the spring is controlled by the movement of the piston *H*, which is governed by the bypassing of the fluid through the passage *J*.

This device is the invention of J. H. Morrow, chief engineer, Great Northern Hotel, Chicago, Ill.

Rules for Weight of Cast-Iron Pipes

The usual method adopted for calculating the weight of cast-iron pipes consists in finding the cubic contents of the metal in inches, and multiplying that by the weight of one cubic inch of cast iron = 0.26 lb.

EXAMPLE—Taking a pipe 12 in. internal diameter, ½ in. thick, 9 ft. long, we have outside diameter 13 in. = 132.732 sq in. area, internal diameter 12 in. = 113.097 in. area.

132.732 — 113.097 = 19.635 sq in. sectional area.
9 ft. = 108 in., hence
19.635 × 108 = 2120.58 cu.in. of cast iron, and
2120.58 × 0.26 = 551.35 lb.

The two flanges, or one socket, are usually reckoned equal to one foot length of pipe.

Another formula for calculating the weight of cast-iron pipes is

$$W = 2.45\,(D^2 - d^2);\ \text{or}\ 2.45\,(D + d) \times (D - d)$$

in which

W = Weight per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
2.34 = A constant.

A very useful approximate rule for the weight of cast-iron pipes is, for a pipe 9 ft long, with flanges at each end, and 1 in. thick, allow 1 cwt. for every inch in diameter, keeping the thickness and weight proportional, either more or less.

EXAMPLES—A 12-in. pipe, 9 ft. long, flanges at each end, 1 in. thick, will weigh approximately 12 cwt.

A 12-in. pipe, 9 ft. long, flanges at each end, ¾ in. thick = 9 cwt.

A 10-in. pipe, 9 ft. long, flanges at each end, ½ in. thick = 5 cwt.

—Björling.

Small Condensing Turbines

By W. J. A. London*

SYNOPSIS—An unusually interesting article on the considerations entering into the design of small condensing turbines, with particular reference to the Terry "return-flow" machine.

Since the introduction of the small direct-connected turbine on a commercial basis, some eight years ago, until recently, fully 90 per cent. of the machines called for were intended for noncondensing service. In the few cases where they were called upon to operate condensing, such as for marine work, little attempt was made at economy, as the operation of these machines condensing was more a matter of convenience than of water rate. It has been acknowledged that the designing of small turbines is much different from that of large machines, for were a small turbine designed on the same principles and lines as a big machine, a hopeless commercial failure would result. There have, therefore, been two distinct fields in turbine work; the principles governing the designs of small and large machines being so much at variance that they might be said to be almost as different as the designs of a steam and a gas engine.

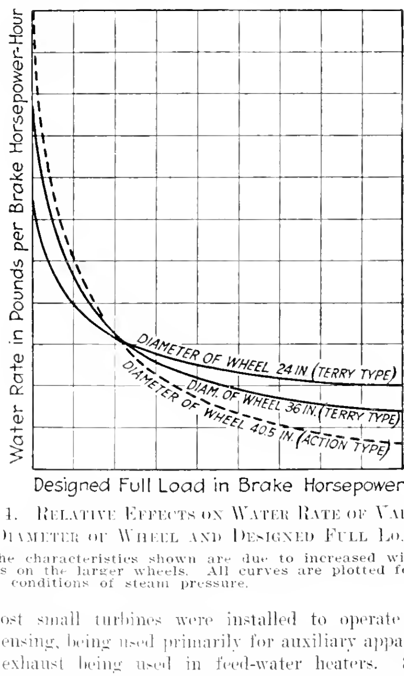


FIG. 1. RELATIVE EFFECTS ON WATER RATE OF VARYING DIAMETER OF WHEEL AND DESIGNED FULL LOAD

The characteristics shown are due to increased windage losses on the larger wheels. All curves are plotted for the same conditions of steam pressure.

Most small turbines were installed to operate noncondensing, being used primarily for auxiliary apparatus, the exhaust being used in feed-water heaters. Small isolated plants were operated noncondensing, the exhaust steam being used for industrial or heating purposes.

For isolated plants, such as small pumping installations of, say 150 to 500 hp., where economy was of much importance and the saving by operating condensing sufficient to offset the first cost, maintenance, etc., the turbine has been at a disadvantage as compared with the reciprocating engine.

The average thermal efficiency of small turbines is in the neighborhood of 40 per cent. With this efficiency all exhaust steam can be utilized without "blowing off," so that no higher efficiency is required or even desirable.

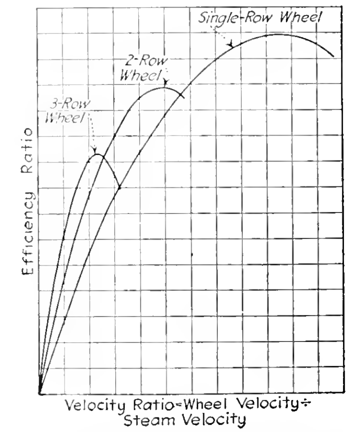


FIG. 2. RELATIVE EFFICIENCIES OF IMPULSE WHEELS WITH VARIOUS NUMBERS OF ROWS OF BUCKETS

Forty per cent. efficiency does not represent the highest available in this class of machine, but it is conceded to be about the highest commercial efficiency. The cost of small turbines varies approximately directly as the square of the diameter of the runner, whereas the efficiency is increased approximately only inversely as the square root of the runner diameter, so any saving in steam consumption must be accompanied by a marked increase in first cost.

Above 500 to 600 hp. the field of the large turbine, where water-rate efficiency is of paramount importance, is approached. These machines operate condensing in the same proportion that the small machines operate noncondensing, and the whole problem of design must be attacked on a totally different fundamental basis.

For powers of, say 150 to 500 hp., condensing, where high efficiencies were desirable, the reciprocating engine until recently had no serious competitor in the steam turbine. The reason for this is obvious. The reciprocating engine was developed, and the meager demand for small high-efficiency turbines did not warrant the manufacture of special machines, and furthermore, the customer would not pay the price that would have to be charged.

Conditions have changed rapidly during the last two years or so, and there is now a big demand for small condensing turbines of high efficiency, both high- and low-pressure, which has led to the development of a third class of machine to meet the requirements of this market. To distinguish this class from the small and the large machines, it is permissible to call it the "in-

*Chief engineer, the Terry Steam Turbine Co.

termediate design." This design should have, as far as possible, the simplicity and accessibility of the small machine with an efficiency approaching that obtainable with the larger units.

When Parsons and DeLaval built their first turbines the main trouble was not with the turbine itself, but with the "other end," or the driven unit. A turbine is of little use by itself, and it was not until it was demonstrated that it had come to stay that generator, pump and blower makers awoke to the fact that they must remodel their apparatus to meet turbine requirements.

Rapid as the turbine development has been, it would have been more so had it not been for the slow development of the "other end." And past events have again repeated themselves in the field of the "intermediate design." This machine would not have been possible had it not been for the rapid strides that have taken place along the following lines: (a) The manufacture at reasonable cost of high-tensile steel for turbine wheels; (b) the increase in permissible speed of generators, blowers, etc.; and (c) the introduction on a commercial basis of the speed-reducing gear.

In POWER of Oct. 28, 1913, a brief description was given of the return-flow condensing steam turbine that had just been developed by the Terry Steam Turbine Co. for this so called "intermediate field."

On the completion of tests of the first machine, several modifications and improvements naturally suggested themselves and are incorporated in the latest designs. For turbines of small power the latest tests show some remarkably good efficiencies, as will be seen by the details of the tests published herewith.

One of the main changes in design has been to carry the principle of the horizontally divided case to the last extreme. In the original return-flow machine the casing was divided horizontally, but the center diaphragms and the center-diaphragm glands were not, whereas in the machine shown all diaphragms, and diaphragm and end glands are thus split, reducing disassembling and assembling time to a minimum. See Fig. 5, right.

In the larger frames another important change has been made. The high-pressure wheel of the Terry type which was incorporated in the first machine has been superseded by a two-row multi-velocity type of wheel running at a high peripheral speed. Extensive experiments have shown that, up to certain peripheral speeds and certain powers with a given thermal drop, the Terry type of bucket is well adapted, but beyond this range the two-row bladed wheel has the advantage. See Fig. 5.

There are several factors entering into the correct design of a wheel of this type other than the actual or theoretical blade efficiency, which make this problem interesting and more complex than one would suppose from a superficial study of the subject on a purely blade-efficiency basis. Disk friction, the power transmitted or rated power of the machine, commercial considerations regarding first cost (which controls the selling price), are all big factors independent of any blade-efficiency theory.

The return-flow turbine is designed so that the pressure in the first stage will be about 2 to 5 lb. above the atmosphere. With ordinary steam pressures of, say 150 lb., and allowing two impulses, the peripheral velocity of the buckets must be about 636 ft. per sec. for best efficiency. At 3600 r.p.m. this calls for a pitch diameter of 40½ in. For three reversals the diameter of wheel would be in the neighborhood of 24 to 26 in.

Fig. 1 shows the relative efficiencies of three types of wheels and the important relation that skin friction and windage bear to the overall efficiency. A "two-velocity stage" wheel is more efficient from a blade-efficiency stand-

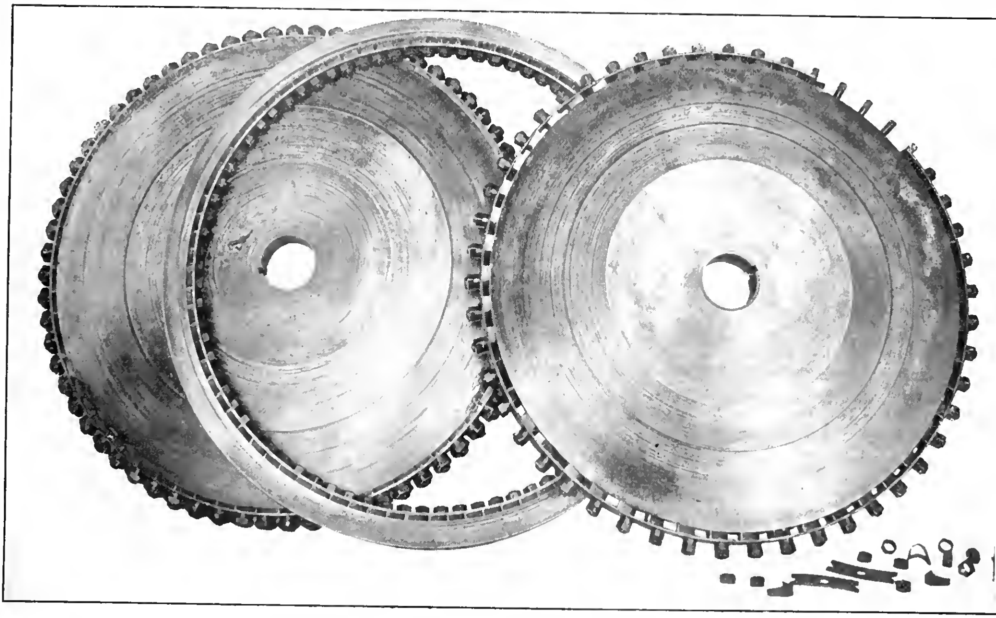


FIG. 3. WHEELS AND GUIDE VANES OF EARLY TERRY TURBINE

point than a "three- or four-velocity stage" (see Fig. 2), yet the friction created by the increased diameter is far more undesirable than one would at first imagine, and the advantage gained by augmented blade efficiency is more than offset by the added losses in other directions.

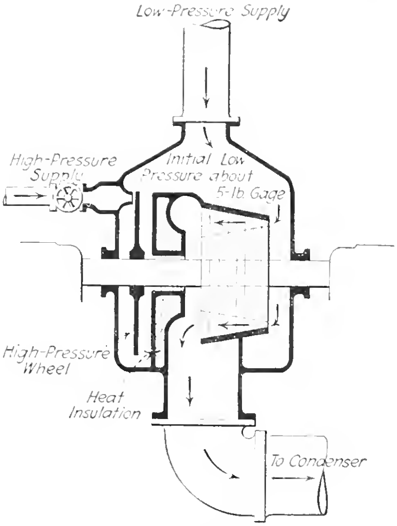


Fig. 4. Diagrammatic Section of Return-Flow Turbine

The various formulas of Stodola, Lewicki, Odell and others, for skin friction of disks, show clearly how big a factor this can be, and while these formulas are somewhat vague and indefinite regarding certain conditions that have to be taken into account, they all agree that this friction loss varies as the second to the 2.5 power of the diameter of the wheel and nearly as the cube of the peripheral velocity. Again, these formulas do not take into account the windage of the blading, which is obviously greater in a bladed wheel than on a bucket wheel.

In reverting to the bladed type of wheel in the high-pressure end, instead of the semicircular-type bucket, it is interesting to note in passing that the first turbine experimented with by E. C. Terry in 1893 was on this principle. Fig. 3 shows the wheels and guide blades of this early machine, the patent number of which is 508,-190.

The Terry type of machine is, primarily and essentially, a noncondensing turbine. Its simplicity and consequent unlikelihood of derangement make it an ideal machine for the duties that it is called upon to perform. Within certain limits of speed, vacuum, etc., the two- or three-stage Terry combination makes an equally good condensing machine, having a thermal efficiency as high as that of the single-stage noncondensing design; but when confronted with the necessity for high speeds, high vacuum and larger powers, the wheel becomes impracticable at the low-pressure end owing to its inability to handle a large volume of steam to the best advantage. In the later machines, therefore, the low-pressure wheel has been replaced by a series of single velocity-stage impulse wheels. That practically all authorities agree that this type of wheel for low-pressure work forms the ultimate turbine element is evidenced by the fact that it is being adopted by practically all turbine builders of both large and small machines, with the one exception of the builders of the reaction, or Parsons, type; and that this type of machine is not adaptable to small powers is evidenced by the fact that the builders themselves resort to the impulse principle in their smaller designs.

Again, the "composite design" of velocity staging in the high-pressure end and pressure staging in the low-pressure must be the last word in turbine development if latest designs of practically all the turbine builders both here and in Europe are any criterion. [See the article on page 436 of this issue.—Editor.]

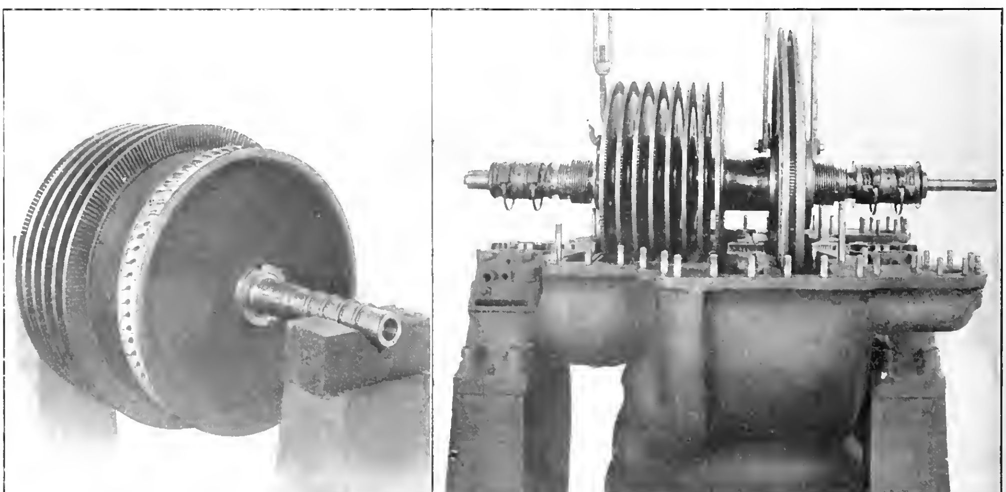


Fig. 5. Rotors of Old and New Designs of Return-Flow Turbines

Old design of rotor having Terry high-pressure bucket wheel

Rotor of new machine having two rows of impulse blading on the high-pressure wheel

The obvious advantage of high vacuum in a turbine, particularly in a low-pressure turbine, with the difficulty of designing, building or keeping glands vacuum tight without the necessity of a water seal with its attendant

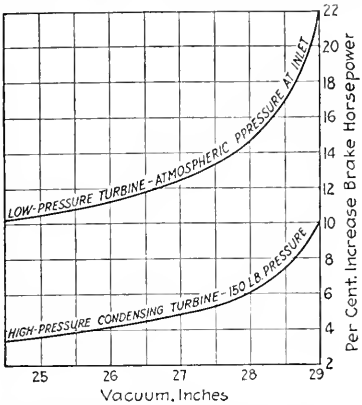


FIG. 6. PERCENTAGE INCREASE IN POWER AVAILABLE (THEORETICAL) PER INCH VACUUM WITH CONDENSING TURBINES

complete envelope of steam above atmospheric pressure, eliminating the possibility of air leaking into the casing. The rotor and the lower half of the casing of the return-flow machine are shown in Fig. 5.

One other important feature in connection with the arrangement of glands on the return-flow turbine is that no supplementary steam supply is necessary for sealing them when under full load, and even at light loads any steam that finds its way through must pass through the low-pressure end of the turbine, thereby doing work, whereas with the ordinary type of steam-sealed glands all the steam which does manage to escape goes directly to the condenser without doing any further work. That this auxiliary steam supply can amount to quite a factor is evidenced by various tests that have been made. Of course, when a machine is new the glands are tight, so that the leakage during this period is imperceptible, but after setting the machine for commercial operation or if it has been in operation for some time, it is hard to know without repeated tests what this steam leakage amounts to. In big machines this is never, however, a serious amount, but in small ones it can be quite a big percentage of the total steam used.

A careful analytical study of the performance of labyrinth glands was made and published by H. M. Mar-

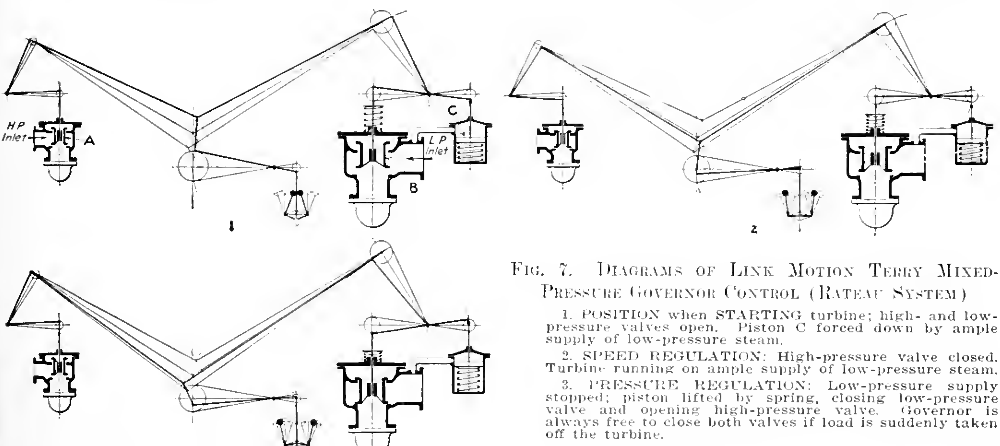


FIG. 7. DIAGRAMS OF LINK MOTION TERRY MIXED-PRESSURE GOVERNOR CONTROL (RATEAU SYSTEM)

1. POSITION when STARTING turbine; high- and low-pressure valves open. Piston C forced down by ample supply of low-pressure steam.

2. SPEED REGULATION: High-pressure valve closed. Turbine running on ample supply of low-pressure steam.

3. PRESSURE REGULATION: Low-pressure supply stopped; piston lifted by spring, closing low-pressure valve and opening high-pressure valve. Governor is always free to close both valves if load is suddenly taken off the turbine.

piping and subsequent sediment troubles, led to the departure from the orthodox straight-flow principle to the return-flow design for the elimination of this long-standing bugbear in turbine work. This question of gland leakage often results in trouble between the turbine and the condenser makers when trying to meet guarantees, while the customer looks on and sees the machine run at a lower vacuum than called for and pays the coal bill anyway.

It is often advocated that with a steam seal on the glands and a little steam blowing outward into the engine room there cannot be any air leaking into the turbine. This contention is wrong, as has been demonstrated many times. It often happens that there is a counter current going on, air traveling along one part of the gland and steam passing out of the glands in the opposite direction, this condition being the hardest possible phenomenon to detect. Fig. 4 shows diagrammatically the construction of the return-flow turbine with the low-pressure end in a

tin, and the formula derived from his experiments is given in his book on steam turbines, as follows:

$$W = 68\,A\sqrt{\frac{P_1\left(1-\frac{l}{x^2}\right)}{V_1\,(N+log_e\,x)}}$$

where

W = Weight discharged in pounds per second;

A = Area in square feet available for flow;

P_1 = Initial absolute pressure in pounds per square inch;

V_1 = Initial specific volume of the steam;

N = Number of points at which the steam is wire drawn;

$x = \frac{P_1}{P_2}$, where P_2 denotes the absolute pressure on final discharge from the last ring of the packing.

This formula checks up fairly closely with actual tests made by the writer on a 2000-kw. machine having a mean labyrinth diameter of 8 in. and 12 elements or restrictions.

From the formula it will be seen that the amount of steam passed by a labyrinth gland is directly proportional to the diameter of the glands. This diameter of

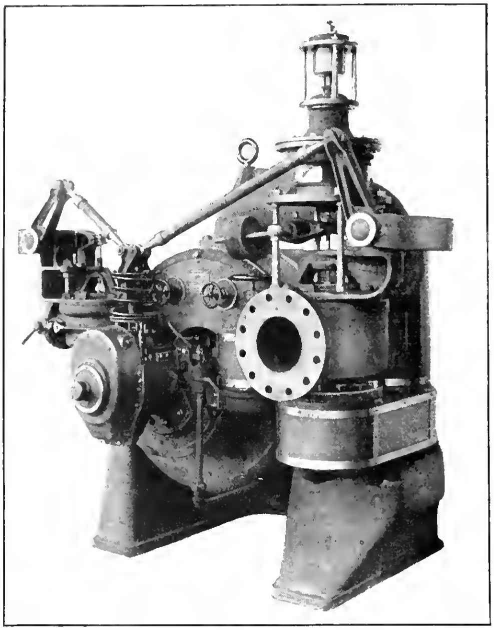


FIG. 8. TERRY RETURN-FLOW TURBINE WITH RATEAU MIXED-PRESSURE CONTROL MECHANISM

gland does not follow any relation to the output of the turbine, and it will be seen that the smaller the machine the larger the percentage of steam that will be passed by the gland; so, as mentioned above, while the amount of steam passed by a labyrinth gland in large machines can be an insignificant factor, it is obvious that in the small machines it can be a serious item. For instance, the figures mentioned above in connection with the 2000-kw. machine show the total steam passed as 177 lb. per hr. On the basis of 15 lb. per kw. this would give a percentage loss due to the glands of 0.6 per cent., whereas reducing this quantity in the ratio of the diameter of the glands, namely, 8 in. to, say 5 in. on a 200-kw. machine, the gland leakage would be reduced to 111 lb., but the percentage of the total steam consumption would be increased to 2.5 per cent., the latter based on a water rate for the smaller machines of 22 lb. per kw.-hr.

Fig. 6 shows the theoretical saving per inch of vacuum in a straight high-pressure condensing and a low-pressure turbine. In the low-pressure machine the vacuum is, therefore, of much importance. We must not look upon this as a question of efficiency so much as a question of how much horsepower one can obtain from a given amount of exhaust steam. Then it means that increasing the vacuum from 27 in. to 28 in. the amount of power available from a fixed quantity of exhaust steam is increased 15 per cent. No precaution is too great for the purchaser to take to insure himself against losses at this point irrespective of any guarantees that may be given either from the turbine or the condenser builder.

The success of the low-pressure turbine intelligently installed is undisputed, but the bulk of the research and development work has been along the lines of the larger machines. The marked saving in these machines has naturally led to the introduction of the low-pressure turbine in small plants such as breweries, ice plants, etc., with just as successful results as with the larger units. Low-pressure turbines of 50 hp. and more have recently been installed, and many more installations are in course of construction. With the exception of a few isolated cases where a fixed supply of exhaust steam can be depended upon indefinitely, the low-pressure turbine has given place to the mixed-pressure machine, the latter having the advantage that should anything happen to the engine or other source of low-pressure steam supply, the full power of the turbine can be obtained when operated with high- or mixed-pressure steam. The return-flow turbine is particularly applicable to low- and mixed-pressure work, as the effect of vacuum in a machine of this kind is of much more importance than in a high-pressure condensing machine.

For satisfactory operation under mixed-pressure conditions and where the low-pressure supply is liable to decrease or fail, a special arrangement of governor mechanism is designed, so that the high-pressure steam is automatically admitted to make up for any deficiency in the low-pressure supply. The system employed by the Terry Steam Turbine Co. on its mixed-pressure turbines is what is known as the mixed-pressure Rateau control, manufactured under license from the Rateau Steam Regenerator Co., the design being modified to eliminate the complicated oil-relay mechanism necessary on larger machines.

The direct-connected governor of the Terry type is used directly connected to the governor valves. The

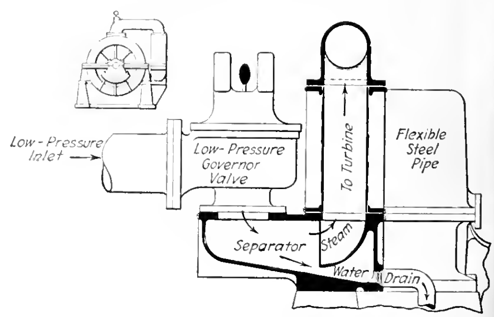


FIG. 9. ARRANGEMENT OF LOW-PRESSURE STEAM INLET ON RETURN-FLOW TURBINE

principle of this mechanism is shown in Fig. 7, and a photograph of the actual machine fitted with this control is shown in Fig. 8. All the levers are mounted on ball bearings to eliminate friction as far as possible. The governor running at high speed has more power than the usual low-speed geared governor and the mechanism itself being balanced by counterweights as shown in Fig. 8, the governor is relieved of all external loads other than to operate the balanced valves.

In all turbine practice, both in high- and low-pressure machines, the question of pipe connections and the elimination of stresses on the turbine is well known to be a serious problem. This is particularly so with the big piping necessary for low-pressure machines, and it is again of further importance in the smaller units, which, on account of their compact size and light weight are susceptible to distortion from outside stresses. The common practice is to bolt the low-pressure valve and piping directly to the turbine casing. This entails considerable risk of pulling the turbine and, consequently, the whole unit out of line, causing vibrations and generally unsatisfactory running. To eliminate this in the return-flow turbine the low-pressure steam supply is not rigidly connected with the turbine proper, but is bolted to an entrainer or separator which in itself is bolted rigidly to the bedplate (see Fig. 9). From this entrainer the steam is led vertically through a flexible steel pipe which leads to the top of the turbine casing. In this way no outside stresses due to the heavy low-pressure steam-supply piping are thrown on the turbine itself. Furthermore, by the introduction of this additional entrainer, drier steam is obtainable in the turbine than would be the case were the inlet piping connected directly to the turbine proper.

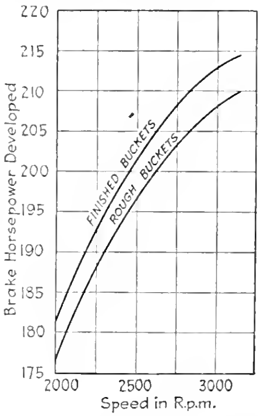


FIG. 10. TESTS OF IMPULSE WHEELS, SHOWING EFFECT OF FINISHING BLADES

Throughout the design of the machine special attention was paid to obtaining the best possible water rate consistent with a compact and reliable mechanical design, and the figures given in the table of some recent tests show some remarkably high efficiencies for turbines of such small power.

The last degree of efficiency can be obtained only by a careful study of the correct areas through the blade passages and by special attention to the finish of the blading in the wheels to eliminate friction and eddies. By the adoption of drawn material for the blading, true areas can be obtained. This machine, as built, conforms closely to calculations, as has been evidenced repeatedly by the careful observation of pressure drops through the various stages, these falling almost exactly in line with the calculated drops. The adoption of polished wheels further enhances the efficiency.

Some interesting experiments were carried out to determine the effect of rough and finished blades and wheels. Fig. 10 shows two curves, one with rough drop-forged blades, the other with blades polished to a true section and with the wheel polished.

Nine-Foot Return-Tubular Boiler

The first 108-in. diameter return-tubular boiler recorded under the laws of the Commonwealth of Massachusetts was recently built at the shops of the D. M.

NINE-FOOT RETURN-TUBULAR BOILER READY FOR SHIPMENT

PERFORMANCES OF TERRY RETURN-FLOW TURBINES

Turbine Number	Initial Steam Pres. before Gov. Valve, Lb.	Vac. Exhaust, In., Hg. Referred to 30-In. Barometer	Load in B.hp.	Load in Kw.	Speed in R.p.m.	Initial Steam Condition, Deg. F. Superheat or Quality	Total Steam per Hr. Actual, Lb.	Total Steam per Hr. Corrected to Dry Steam, Lb.	Water Rate per Kw.-hr. Actual, Lb.	Water Rate per B.hp.-hr. Actual, Lb.	Water per B.hp.-hr. Corrected to Dry Steam, Lb.	Thermal Efficiency Ratio	Water Rate on Which Efficiency Ratio Is Based	Test
1383	128.8	25.64	368.1		3640	10.6	6297.8	6376		17.10	17.29	0.535	Dry steam	A
1383	128.8	28.00	441.3		3640	Dry		6370			14.43	0.561	Dry steam	B
1383	128.8	24.16	254.5		3640	10.0	5016.0	5069		19.7	19.90	0.491	Dry steam	C
1383	128.8	28.00	343.0		3640	Dry		5069			14.77	0.518	Dry steam	D
1383	7.03	25.60	307.0		3600	85.0	8086.0			26.35		0.606	Actual	E
1333	5.20	23.75	193.0		2000	89.0	7076.0			36.68		0.529	Actual	F
1383	2.46	24.75	205.5		3000	93.7	6063.0			29.48		0.649	Actual	G
1383	8.25	24.35	307.5		3300	76.5	8340.0			27.10		0.639	Actual	H
1874	1.75	25.30		106.4	2500	12.0	6220.0		58.5	38.4		0.521	Actual	I
1874	100.4	25.8		98.8	2462	0.981	3440.0	3319	34.85	22.85	22.00	0.443	Dry steam	J
1874	100.0	0.0		98.2	2525	12.5	6065.0	6142	61.8	40.58	41.10	0.414	Dry steam	K
1750	125.5	25.25	416.9		3600	26.9	6400.0	6575		15.35	15.78	0.597	Dry steam	L
1750	125.5	28.00	490.9		3600	Dry		6575			13.39	0.609	Dry steam	M
1750	125.0	26.57	321.7		3600	21.0	5133.0	5245		16.30	15.96	0.558	Dry steam	N
1750	125.0	27.36	233.4		3600	25.0	3771.6	3870		16.17	16.59	0.512	Dry steam	O
1750	125.5	25.25	419.6		3200	26.9	6400.0	6575		15.26	15.67	0.604	Dry steam	P
1750	125.5	25.25	407.6		2800	26.9	6400.0	6575		15.71	16.13	0.587	Dry steam	Q
1750	125.5	25.25	384.9		2400	26.9	6400.0	6575		16.63	17.08	0.554	Dry steam	R
1750	0.25	26.01	67.0	....	500	116.0	6874.0			102.6	....	0.175	Actual	S
1750	0.25	26.01	167.5	....	1500	110.0	6874.0			41.04	....	0.438	Actual	T
1750	0.25	26.01	237.6	....	3500	110.0	6874.0			28.94	....	0.620	Actual	U
1750	0.25	26.01	227.8	....	4000	110.0	6874.0		..	30.19	....	0.595	Actual	V
2044	124.7	26.49	343.0	....	3600	27.4	5165.0	5305	.	15.06	15.47	0.578	Dry steam	W
2044	125.0	26.49	295.0	....	3600	Dry	...	4665			15.82	0.566	Dry steam	X
2044	125.0	28.00	325.0	....	3600	Dry	...	4665			14.36	0.568	Dry steam	Y
2044	125.0	26.49	240.0	....	3600	Dry	....	3990		..	16.62	0.539	Dry steam	Z
2044	125.0	26.49	180.0	....	3600	Dry	...	3260	.	..	18.10	0.495	Dry steam	AA

Dillon Steam Boiler Works, Fitchburg, in accordance with the Massachusetts state laws, for a safe working pressure of 125 lb. The recorded number given to it at the State House in Boston is 974.

The boiler is 9 ft. in diameter and 18 ft. long. The firebox-steel shell plates, and the flange-steel heads are ⅝ in. thick. The boiler has 200 4-in. by 18-ft. Parkesburg charcoal-iron tubes, and has a butt-strap, double-riveted steam drum 30 in. diameter by 6 ft. long. The bare boiler without tubes weighs 27,000 lb. (13½ tons) and complete with all castings and fittings, 84,440 lb. (42.22 tons).

In order to make the boiler lighter for transportation but sixteen tubes were put in at the time of shipment. These were to brace the tube sheet, the rest of the holes being plugged so that the boiler would not sink in case it fell overboard while unloading it from the vessel to the lighter, or in case it was necessary to float it from the boat to the shore. It was shipped to Porto Rico.

The boiler is of interest on account of its large diameter, and because it is the first of its size recorded under the laws of the Commonwealth of Massachusetts.

Metallurgical and Special Furnaces*

By Osborn Monnett†

SYNOPSIS—Industrial furnaces, hand-fired or stoker equipped, specially designed to eliminate smoke.

In studying the smoke problem it will be noticed that there are a great many furnaces burning coal and making smoke other than those installed under a boiler. In the various industries common to a large city enormous quantities of coal are consumed in metallurgical and special furnaces which have no application whatever to the generation of steam. The nature of the work demanded of these furnaces is such as to make them peculiarly susceptible to the making of smoke; in fact, some of the processes require such a low rate of combustion that it is difficult to get the proper temperature for complete combustion. In this class one of the worst smokers has been the ordinary hand-fired annealing oven.

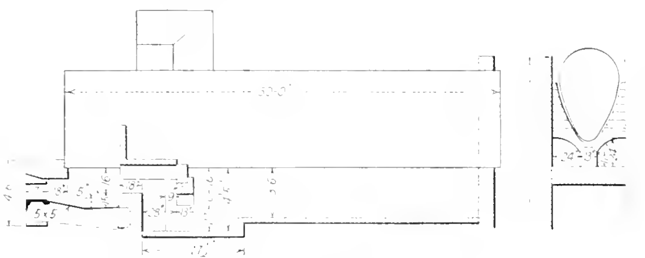


Fig. 1. Fertilizer Tank with Modified Double-Arch Bridge-Wall Setting

On a large scale the use of powdered coal has successfully cleaned up this class of plant and has generally resulted in a substantial saving of fuel over the hand firing, although the investment required is considerable. On a smaller scale, or where the product is of small size, such as automobile parts, producer gas has been successfully used. Producer gas is also well adapted for enameling ovens, and china, pottery and terra cotta kilns.

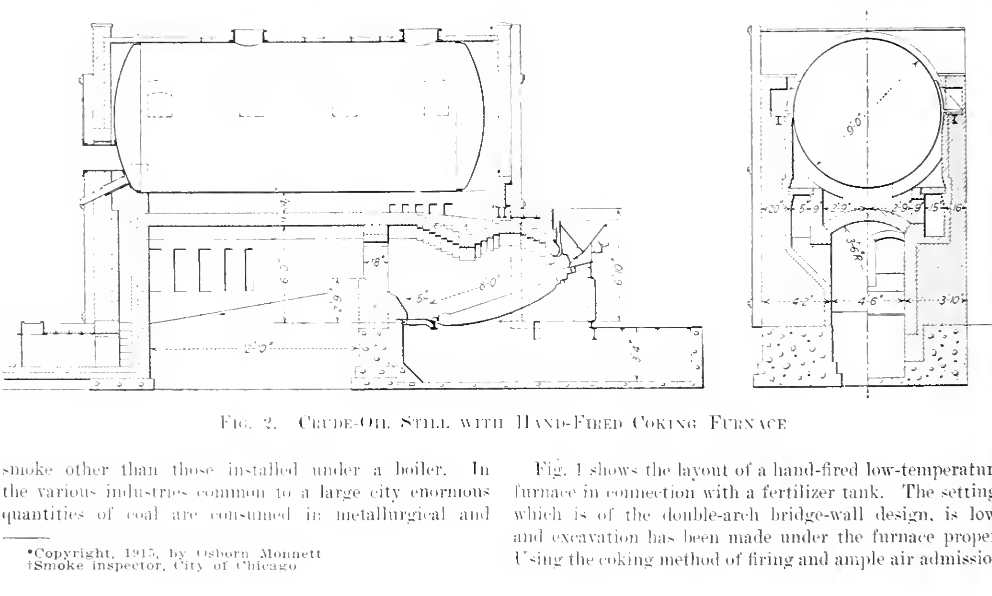


Fig. 2. Crude-Oil Still with Hand-Fired Coking Furnace

Fig. 1 shows the layout of a hand-fired low-temperature furnace in connection with a fertilizer tank. The setting, which is of the double-arch bridge-wall design, is low, and excavation has been made under the furnace proper. Using the coking method of firing and ample air admission

*Copyright, 1915, by Osborn Monnett
†Smoke inspector, City of Chicago

for the semibituminous coal, this furnace can be operated without dense smoke, but it requires careful attention and this is difficult to get in this class of plant.

A crude-oil still, with a special hand-fired furnace arranged for low rates of combustion, is shown in Fig. 2. This furnace is designed for the coking method of firing with semibituminous coal. There is considerable brickwork in the furnace, designed not only to give good mixture, but also to isolate the shell from the heat to prevent burning of the still. Too high a temperature at any one point would be disastrous, so the furnace is provided with a spring arch the entire length of the tank. Coal is charged on the front of the grate and pushed down when fully coked.

Natural gas and fuel oil are also used for this and similar work where the price is low enough so that these fuels may compete favorably with coal. When burning the latter any of the various gravity-feed furnaces can be used. Fig. 3, showing a small Burke furnace attached to a pot annealing oven, is typical of this class of service. Powdered coal and producer gas are also being used in this work. There is probably no class of metallurgical work in which one or the other of the above fuels will not give satisfaction.

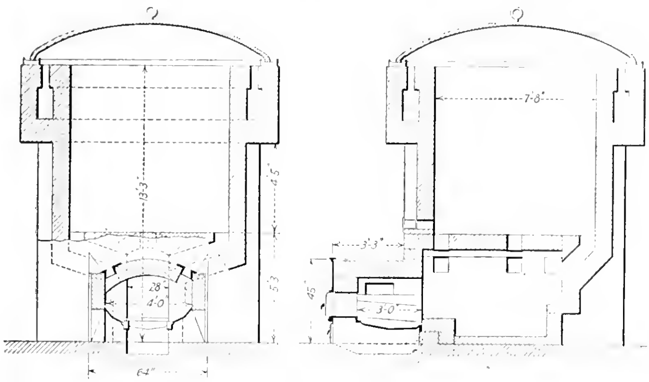


Fig. 3. Pot Annealing Oven and Burke Gravity-Feed Furnace

As mentioned before, the underfeed stoker is peculiarly adapted to special furnace work, owing to the fact that the necessary air for combustion is supplied by mechanical means. Figs. 4 and 5 show typical reheating furnaces equipped with this type of stoker. Rotary drying is another service in which the underfeed stoker works out well. Natural draft on this work is an uncertain quantity, placing at a disadvantage stokers depending on a stack for their air supply. A furnace arranged for connection to a rotary dryer is shown in Fig. 6. This outfit is adapted to the drying of fertilizer, garbage, blood, sand, sugar-beet pulp, or any similar substance from which it is desired to drive off the moisture.

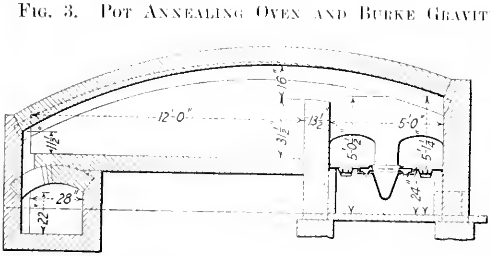


Fig. 4. Jones Underfeed Stoker Serving Reheating Furnace with Underground Breeching

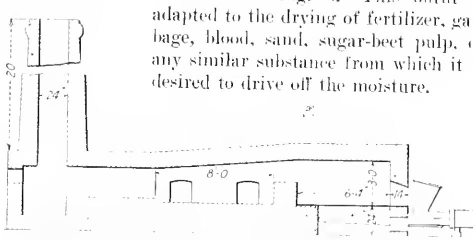


Fig. 6. Rotary Drying Furnace Fitted with Underfeed Stoker

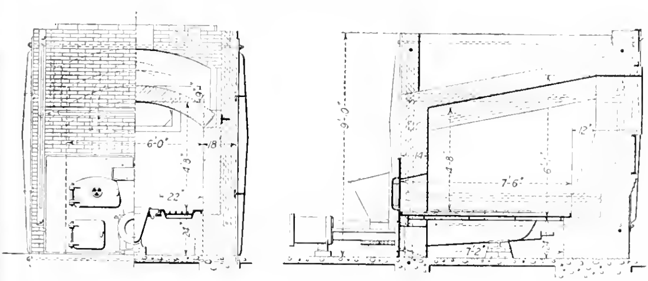


Fig. 5. Typical Reheating Furnace with Underfeed Stoker and Independent Stack

Ocean Volume to Land Area—One per cent. of the contents of the oceans would cover all the land areas of the globe to a depth of 290 ft.—U. S. Geological Survey.

⁂

Horsepower and Torque Defined—It is important to understand clearly the difference between horsepower and torque. The former is the rate of doing work, while the latter is only one of the quantities making up horsepower. The torque of a motor is sometimes defined as the pull or force exerted at the surface of the armature, multiplied by the radius of the armature. For commercial purposes, however, is is defined as the pull exerted at a certain radius from the shaft center. For convenience this pull is usually expressed in pounds and the radius in feet, which, multiplied by the peripheral speed, gives an expression in foot-pounds which is readily reducible to horsepower. Assuming that the force is applied at a distance of one foot from the center of the shaft so that r (radius) = 1, then

$$\text{torque (T)} = \frac{\text{hp} \times 33{,}000}{2\pi \times \text{r.p.m.}} = \frac{\text{hp} \times 5252}{\text{r.p.m.}}$$

From this it is evident that for a given motor and a given horsepower, the torque varies inversely as the speed. If the first definition of torque is assumed, that is, the force acting at the surface of the armature—it is apparent that the torque would be dependent on the diameter of the armature as well as the speed; whereas, by the second definition, it is independent of the armature diameter. In motor applications one is concerned with the torque exerted on the motor shaft and not at the surface of the armature.

High-Tension Switching Systems

By John A. Randolph

SYNOPSIS—Factors determining the extent and arrangement of high-tension switching equipment to be employed, and descriptions of several of the more common systems in use.

In determining the arrangement of a high-tension switching system several fundamental factors must be considered. One is the nature of the service, inasmuch as the scheme of connections for a lighting and industrial service is generally different from that of a system feeding railways. Another is the type of station (central station or substation), which will largely determine certain features of the design. The magnitude and extent of service will also have an important bearing, as will the number of high-tension feeders and the voltage to be carried. The distance of the station from its center of distribution is a vital factor, as is also the space available for installation purposes. Safety to life and property should not be overlooked, although this is perhaps of more importance in the design of the compartments and supports than in the determination of the diagrammatic layout. Furthermore, the money available for construction purposes is a governing factor, and precautions must be taken to insure continuity of service at all times.

In regard to the nature of the general service, it can be said of the railway system that, owing to the large amount of exposed conductors, such as third rails, trolley wires, underground contact rails and ground returns, the liability to short-circuits and consequent interruptions in operation is somewhat greater than on lighting systems, especially such of the latter as are installed in underground conduits. Therefore, greater precautions against shutdowns are advisable for the railway station.

The number of high-tension feeders and the voltage carried will depend largely upon the extent of the service and the distance of the source of supply from the distribution center. If the generating station, for instance, is run by hydro-electric power and is located in the mountains a long distance from the point at which the energy is used, it will be necessary to make the number of high-tension feeders as low as possible in order to save transmission-line costs. To do this the line voltage must be raised in order to transmit the given power over the limited cross-section of conductor. This will permit a comparatively small number of high-tension switches being used, but they will be larger and more cumbersome than those for lower voltages. Wide clearances between conductors and between live parts and ground must be maintained in extra high-voltage work; therefore, more space is required for a given amount of apparatus and conductors than in the case of lower-voltage installations. If this space is limited it may be necessary to limit the output of the station. Here also, the factor of safety to life and property is of more importance than in other cases.

The money available for construction purposes is a determining factor in that it may be necessary to sacrifice many advantageous features to save expense. This is often hazardous, but exigencies may demand it. To conform to this restriction it may be necessary to use but one bus, with a correspondingly smaller number of switches, or to otherwise arrange the switching apparatus in the simplest possible manner, which is by no means the safest. However, in connection with the first cost, the future continuity of service should be borne in mind. Lack of patronage, due to unreliable service, may cause the company to lose in a comparatively short time an amount greater than the saving effected by limiting the flexibility of the switching system.

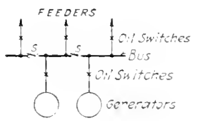


FIG. 1.

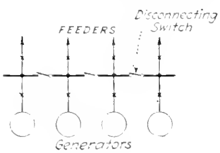


FIG. 2.

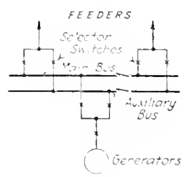


FIG. 3.

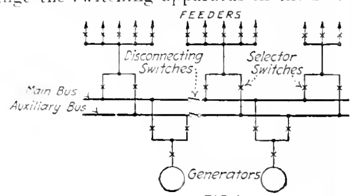


FIG. 4.

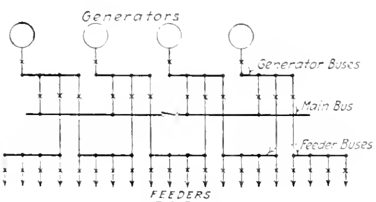


FIG. 5

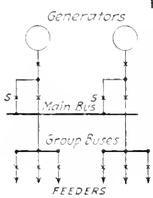


FIG. 6.

Single-Bus System

The simplest method generally employed for the arrangement of switches and buses on a high-tension system is shown in Fig. 1 (the "bus" in this case signifying one set of busbars). One bus is used to which all the generators and feeders are directly connected, there being only one oil switch to each generator and to each feeder circuit. Disconnecting switches *S* are generally installed for isolating sections on which serious defects exist or on which it is desired to make repairs. This arrangement is often used in railway substations. To add to the flexibility of such a plan, the machines and feeders are sometimes connected to the busbars at the same points, disconnecting switches being placed between these points, as in Fig. 2. This provides better facilities for the isolation of feeders and machines with their corresponding bus sections.

The single-bus system has the advantage of minimum space and comparatively low initial cost, but it has the disadvantage of not making possible the ready transfer of machines or feeders from the sections to which they are normally connected, to other sections. On a single-bus system such as shown in Figs. 1 and 2, the machines and feeders always receive or deliver their energy at a fixed point. Moreover, if a sectionalizing switch is opened, the sections on either side of the gap are entirely separated and work independently.

Two-Bus System

In the larger modern central stations, it is customary to install two buses—the main bus and the auxiliary bus. There are several methods by which the feeders and generators may be connected to the buses. In one of these, shown in Fig. 3, two selector switches with each feeder and alternator permit a connection to either of the two buses. Sectionalizing switches are also located at intervals in each bus. With this arrangement, if it becomes necessary to isolate a section of either bus the feeders and machines previously connected to that section can be easily transferred to the other bus without interruption in the service. Moreover, if the demand on one bus becomes so heavy that it is in danger of becoming overloaded, part of the load can be transferred to the other bus; or, where two buses are used, it is possible to so divide the load on the station that accidents occurring on one part of the system will not affect the system as a whole.

Group System

An arrangement commonly employed in central stations and on railway systems using a number of substations for distribution is shown in Fig. 4. In this scheme a main and an auxiliary bus are used, but the feeders, instead of having independent connections to the two operating buses, are connected to group buses which, in turn, are connected by selector switches to the main and auxiliary buses. An advantage of this arrangement is that fewer selector switches are necessary; also, in cases of emergency, a number of feeders can be transferred simultaneously from one operating bus to the other, thus saving time and simplifying the work of the operator.

Another diagram making use of a group bus for feeders is shown in Fig. 5. In addition to the main bus and the feeder group buses, there is a series of generator buses. Four circuits are connected to each generator bus section—one comprising the feed from the generator or other source of power, another a connection to the main bus, and the other two serving to connect the generator bus to two adjacent feeder group buses. The function of the main bus is to tie all the individual buses together and to maintain the power supply on any generator bus after its particular machine has been shut down. Furthermore, it serves to equalize the load on all the generators. The outgoing feeders are connected to the group buses. Inasmuch as every group bus is connected to two adjacent generator buses, it is possible to isolate a generator or group bus without serious inconvenience to the system as a whole. Moreover, all or a part of the main bus can be disconnected from the rest of the system without interrupting the service. Another advantage is that one or two groups of feeders can be fed from either one or two generators independently of the rest of the system. This affords especial convenience in testing.

An arrangement somewhat similar to that of Fig. 5, but incapable of as many combinations, is shown in Fig. 6. A main operating bus is used whereby all the generators and all the feeder groups, or both, may be tied together through the main bus switches S. The generators may be disconnected at will as long as the main bus is kept alive and the switches S are closed. Moreover, the individual feeder groups may be isolated from the main bus as long as the respective generators for those groups are kept running. A disadvantage of this system is that an isolated group, if kept alive, is absolutely dependent upon one particular generator. Furthermore, if the main feed line of the group is out of commission the group itself is also put out of service. The same result will ensue if the generator bus is out of service. In the more flexible arrangement of Fig. 5 these disadvantages do not exist, inasmuch as every group has a connection to two separate generator buses.

Multiple-Voltage System

In the systems described thus far the voltage on the buses has been the same as that of the generators. However, where two or more services with different voltages are to be supplied from one central station, it is often

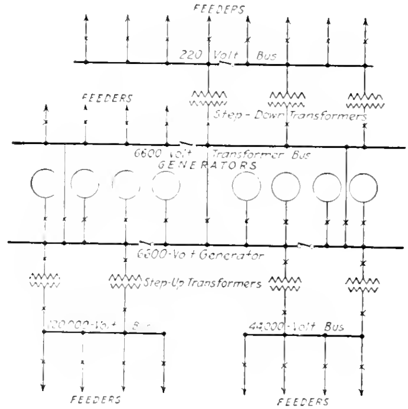


Fig. 7.

advisable to install a separate bus for each service; such an arrangement is illustrated in Fig. 7. The generator voltage of 6600 determines the pressure of the generator bus. However, for the 40,000- and 120,000-volt services, separate buses are installed whose power supply comes from the generator bus, but with the voltage increased by means of step-up transformers. A 220-volt bus for low-tension work is fed through step-down transformers whose primaries are joined to a 6600-volt bus fed directly from the generator bus. For flexibility the various buses are divided into sections, and between these sections are switches which can be quickly opened or closed at the will of the operator.

⁂

The Expansion of Steam Lines may be found by the formula

$$E = C \times (T - t) \times L$$

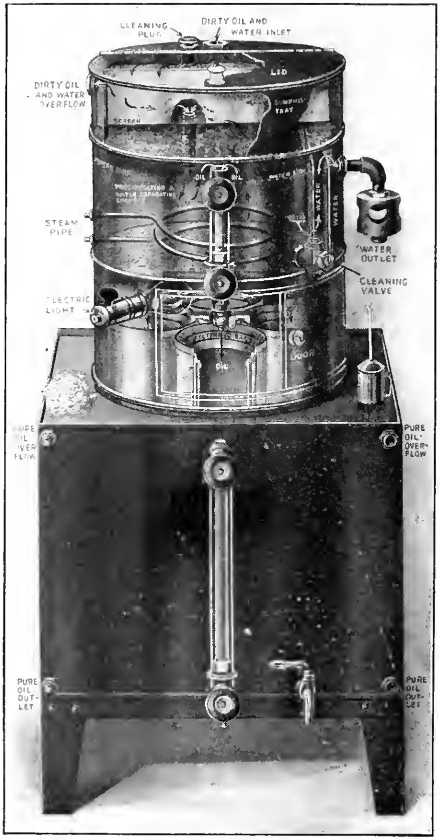
when

E = Expansion in inches;
T — t = Temperature difference;
L = Length of pipe in inches;
C = The coefficient of expansion of the metal of which the pipe is made.

The coefficients of expansion of various pipe materials are: Cast iron, 0.0000065; steel, 0.0000067; wrought iron, 0.0000068, copper, 0.0000095; brass, 0.0000105.

Nugent Improved Oil Filter

The accompanying illustration shows one of the standard filters now being made by Wm. W. Nugent & Co., of Chicago. This particular design may be circular or square in section. It is made in eight different sizes, the capacities being from 6 to 100 gal. per hr., respectively. Multiplication of the filtering chambers will, of course, give an apparatus of any desired capacity. The cylindrical filtering and water-separating section, shown at the top in the illustration, is independent of the reservoir, and is supplied separately if desired. A tank suitable for oil storage may be available at the plant and if appearances do not count an oil barrel may be used. In the latter case the barrel is turned upright and the filtering chamber set over the open end.



Nugent Improved Oil Filter

From the phantom view the path of the oil from inlet to storage may be traced. In the top part are two semicircular sections, one known as the dumping tray and the rear half as the screen chamber. If the filter is connected to an oiling system, the dirty oil and water which may be present enter the dumping tray through the inlet shown. By raising the lid it may also be poured into this compartment. In the vertical wall separating the two sections is a fine-mesh copper screen through which the oil passes into the screen chamber. From here it flows downward through a short pipe into the water-separating and precipitating chamber. It enters under the surface of the water, rises to the top and overflows into a central pipe supplying the filtering bags. The water passes under the inner partition, shown at the right of the chamber, and over the second partition to the outlet.

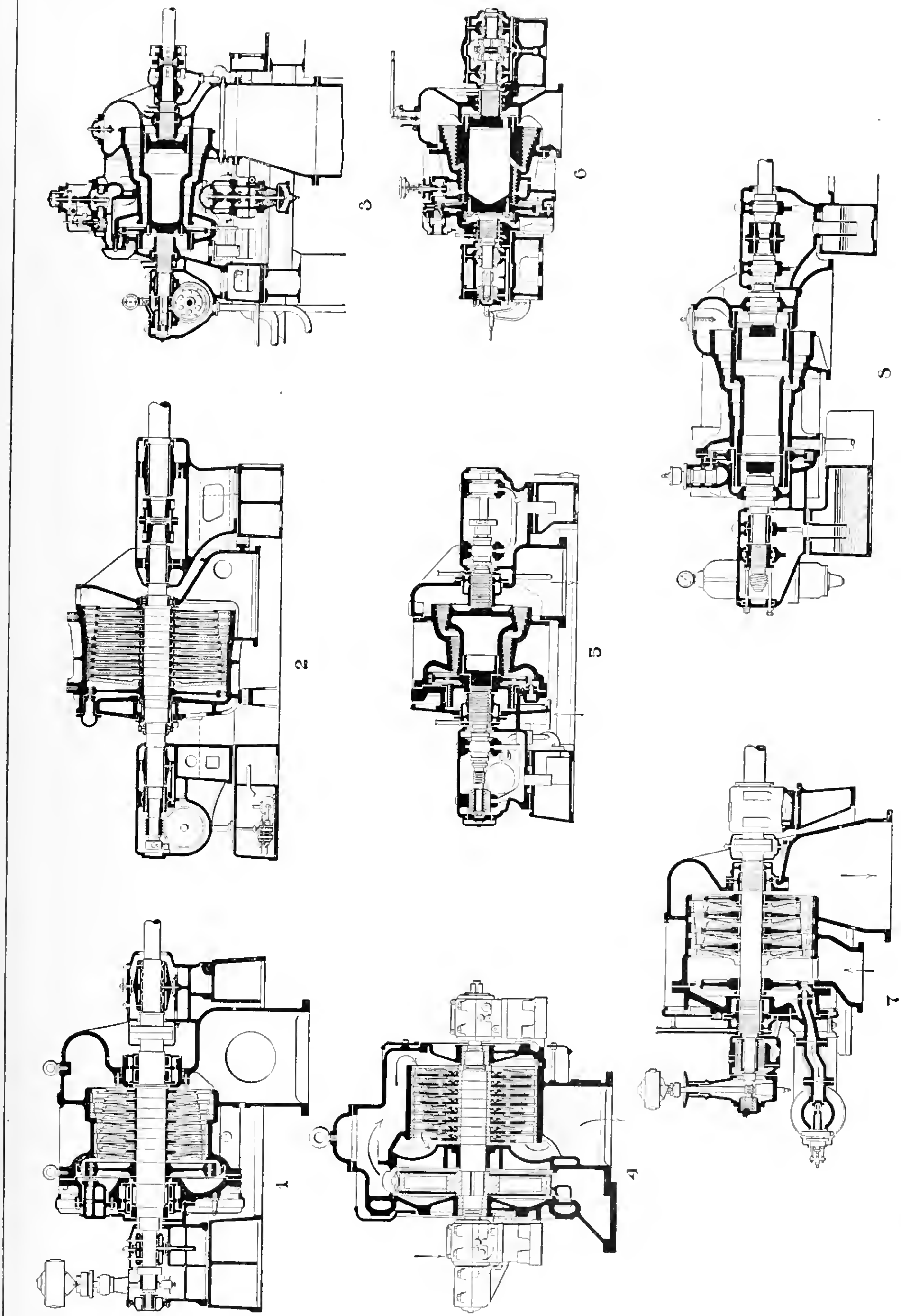
Depending on the size of the filter, one, two, three, four, six or eight sets of filtering bags are provided, three in a set, all on independent rings. The two smaller ones are made of comparatively thin fabric, while the material forming the largest is much heavier. An electric light has been provided so that the filters may be inspected through the sliding door shown in the illustration. The machines having four, six or eight sets of bags are suspended from a central spindle and each may be rotated to a position in front of the door. The cock controlling the drip at this point may be closed and the bags inspected or cleaned. The pipe leading from the screen chamber is of such a size that it cannot supply enough oil to flood the filters. If more should come to the dumping tray than can be cared for, the surplus escapes through the overflow at the top and eventually is returned to the filter. Other features are the steam coil in the water-separating chamber and the facilities for cleaning.

The Composite-Type Steam Turbine

Five years ago we called attention to the evident tendency to unification in turbine types, and the adoption by several builders of the velocity-stage for the initial expansion, and by the builders of velocity-stage turbines of single-velocity impulse or reaction stages for the lower ranges. We pointed out that by allowing the initial expansion to take place in a single set of nozzles, and using a velocity-stage of two rows of moving and a single row of reversing buckets to absorb the velocity so generated, the steam is reduced in pressure from, say 150, to 30 lb. before it is introduced to the turbine case, decreasing the pressure upon the balancing plates or dummies, diminishing the temperature to which the rotor drum and shell are subjected, and eliminating the long section of short blades, admittedly the least efficient of the reaction turbine, on account of their large windage in the dense medium of the high-pressure steam, and of the large proportion of their clearance to the active surface.

The anticipations expressed in this article have been realized, and we present upon the opposite page a number of the machines of this composite type as now built by prominent companies. The presentation is, however, by no means complete, and should include the General Electric Co. and the Westinghouse Machine Co., if not other American builders. The builders of the turbines, sections of which are shown, are as follows:

1. Bergmann, Berlin.
2. British Westinghouse, Manchester.
3. Melms & Pfenninger, Berlin and Munich.
4. Terry, Hartford, Conn.
5. Gutehoffnungshütte, Oberhausen.
6. Brush, London.
7. Allgemeine Elektricitäts Gesellschaft, Berlin.
8. Brown Boveri, Baden.

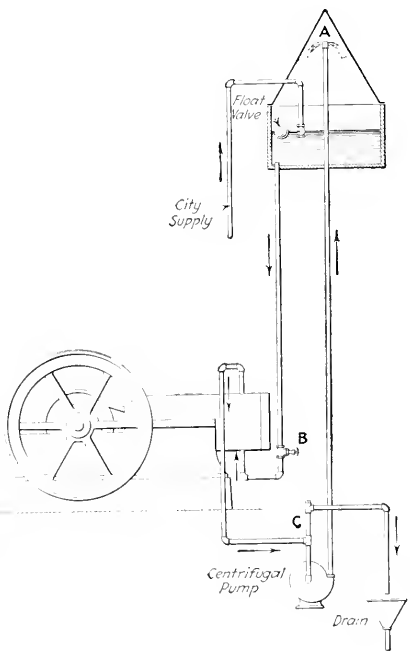


Examples of Steam Turbines of the Composite Type

Gas-Engine Cooling Water

By G. A. Field

The temperature of the jacket water should be controlled to suit the individual case. For instance, large engines require cooler cylinders than smaller ones, and oil engines often require slightly higher temperatures than those burning gas or gasoline, because of the tendency of the oil to condense on the cylinder walls. In automobile engines the jacket water often reaches the boiling point without any serious results. Under average conditions the temperature of the cooling medium on entering the cylinder jacket will not exceed 60 deg. F. and on leaving should not exceed 160 deg., 150 deg. being better practice. Should the temperature of the cooling water exceed 185 deg., there is danger of deposit in the jacket.



Arrangement of Cooling System

As a safeguard against incrustation of the water jacket soda may be introduced, about a pound a month being used for every 17 cu.ft. of reservoir capacity. The jacket should be flushed out frequently. Another method is to fill the jacket space with one part sulphuric acid and ten parts water and allow it to remain over night.

For small engines, not hopper cooled, but using the thermo-siphon system, ordinary tanks or reservoirs are used. In this case the bottom of the reservoir should not be below the water outlet of the cylinder jacket, as the circulation is maintained solely by the difference in the density of the water due to the difference in temperature at the inlet and the outlet. The height of the water in the reservoir should not be less than four inches above the discharge of the return pipe. The capacities of reservoirs of this type are, of course, dependent upon the size of the engine and should be from 50 to 60 gal. per hp.

Water injection in various quantities directly into the combustion chamber is also used, but has not as yet displaced the water jacket to any great extent. A very small quantity of water is commonly injected with the fuel of oil engines to prevent preignition and also, by lowering the temperature of the burning charge, to prevent the decomposition of the fine particles of oil before evaporation is fully attained. This results in a decrease in the amount of carbon deposited in the combustion space.

It is estimated that about one-third the total heat supplied to the engine is carried away in the cooling water. Manufacturers guarantee a heat consumption of from 11,000 B.t.u. per b.hp.-hr. for full load, to 19,000 or 20,000 B.t.u. for one-quarter load. Therefore, with a safe allowance for ordinary working conditions of 12,000 B.t.u. per b.hp.-hr., based upon full-load rating, it will be seen that about 4000 B.t.u. per b.hp.-hr. must be carried away by the cooling medium.

As one B.t.u. is required to raise 1 lb. of water 1 deg. F., for an average range of 90 deg. it will require $4000 \div 90 = 44.5$ lb. of water, which is equivalent to approximately 5.35 gal. per b.hp.-hr.

Practical experience shows that small hopper-cooled engines require from 0.3 to 0.6 gal. of cooling water per b.hp.-hr., while larger engines using forced circulation should have a pump capacity of from 10 to 15 gal. per b.hp.-hr.

An economical and efficient arrangement for recooling the jacket water, and also providing for loss due to evaporation or danger of the pump failing to operate, is shown in the attached sketch. The cooling tower may be placed on the roof at some elevation above the engine, and it should be in the open air. The hot water is delivered along the under side of the ridge at *A* and is sprayed outward on each side against the sloping sides through holes drilled in the pipe. The sides are made of fine woven wire, which permits free passage of the air and carries the water down to the open tank below. Water enters the tank from the city supply pipe until the level reaches a sufficient height to close the float valve.

After starting the engine, the valve *B* is opened and the centrifugal pump is started. The pump, being at the lowest point in the line, is always primed and the cooling water immediately takes the circuit downward from the tank through the water jacket of the engine, into the pump, and upward to the spray and back to the tank.

Should the pump fail to operate properly or stop altogether, the circulation will still be maintained; the water being constantly replenished by the city-supply pipe through the automatic float valve. After passing through the cylinder jacket the water, instead of passing through the pump, will flow upward through the pipe *C* and into the drain. By means of the float valve, all losses due to evaporation are replenished, making the system automatic.

The pump should, if possible, be belted to the engine, but may be run by an electric motor. In shutting down the engine the valve *B* is, of course, closed and the pump stopped.

Manual Training Schools in the United States numbered 279 in 1913, with 65,699 students.

A Large Wooden Flywheel

Engine wheels of large size, especially those designed for high rim speed, are, in many instances, being built up with wooden rims, and many old-style cast-iron wheels on large engines are being replaced with the modern wood-rimmed wheel. Such a change has recently been made at the large cotton mill operated by the Berkeley Co., at Berkeley, R. I. The two independent Corliss engines at this plant, each having a separate flywheel and shaft, are operated together as a cross-compound, in conjunction with an independent condensing apparatus. The cylinder of one is 26 and of the other 52 in. in diameter, each having a 72-in. stroke. The wheel of the high-pressure engine, 25 ft. in diameter and 88 in. width of face, was originally of cast iron, the centers being in two pieces forced upon the shaft, and the arms and segments, eight of each, being cast separately.

the pad on the rim segment, to prevent further development of the cracks. Such repairs as could be made between a Saturday night and the following Monday morning were attended to, and the wheel was operated with the mill load the greater part of the following Monday morning, when it was thought wise to shut down and note conditions. It was found that the pad at both ends of the segment adjoining the one originally cracked had developed fractures, and special steel patches had to be made up and applied to those segments before the engine could be again operated. Meanwhile, it had been determined that the wheel, cracked as described, was not safe to run, no matter how well repaired and patched up, and an order was placed for a modern wheel of such design as would permit the engine to be operated at any desired speed and still have a greater factor of safety than could be had with an all cast-iron wheel.

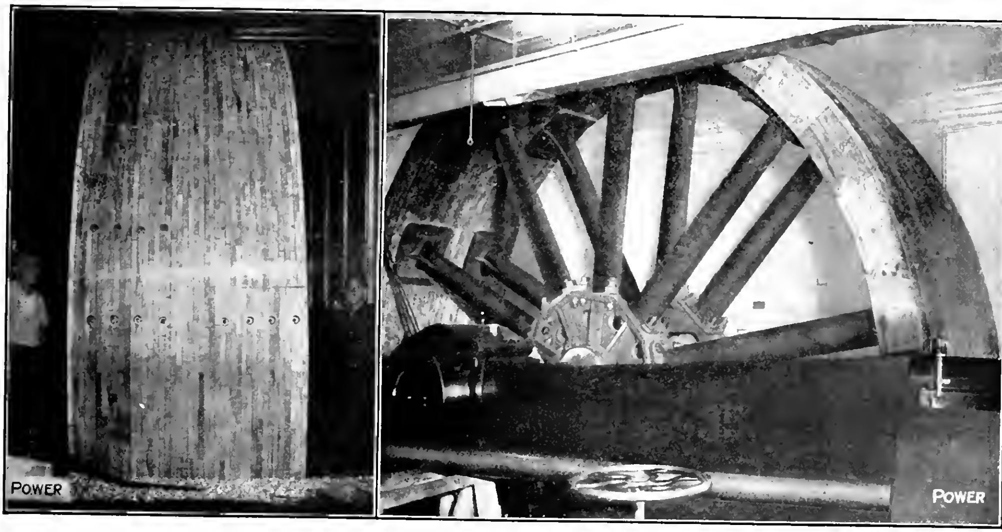


Fig. 1. Twenty-Five-Foot Flywheel with Wooden Rim at Berkeley (R. I.) Cotton Mills

This wheel was designed for about 50 r.p.m., and at the time of its installation so large a wheel, with only eight arms and eight rim segments, was considered to have an ample factor of safety when running, as this ran, with a rim speed of 65.45 ft. per sec. Later, the speed of the engine was increased to 60 r.p.m., giving it a rim speed of 78.54 ft. per sec., and as a matter of insurance, the built-up iron wheel was stayed for additional strength by applying wrought-iron bands on the shaft on each side of the wheel hub and having steel stays reach therefrom to the bolts securing the joints of the rim segments; these stays being 16 in number, twice as many as there were arms in the wheel.

In this manner the wheel was operated for a considerable time and was carefully inspected at given periods. Some months ago, during such a week-end inspection, cracks were noticed in the pad of one rim segment at the point where the wheel arm was bolted to the rim, and while the cracks found were not such as would indicate any necessity for condemning the wheel, it was thought wise to apply special wrought-steel patches to strengthen

The new wheel was designed, built and installed by the William A. Harris Steam Engine Co., of Providence, R. I., and is of the same size as the one replaced, but the hubs are in two pieces, designed for a clamping fit to the shaft instead of being forced into place, and the arms, which are cast separately, are 20 in number, of oval cross-section and hollow, there being two sets of these arms, 10 in each set. The rim is 14 in. thick, built up of white pine, and while the new wheel is superior in every particular to the old type of wheel and has a greater factor of safety, it weighs only about the same as the iron one which it replaces, and does not, therefore, bring any greater weight on the main bearing, the original shaft being re-employed. The total weight of the new wheel is about 80,000 lb., of which 60,000 are in the iron work of the hubs and arms, and 20,000 in the wooden rim. The patched-up and repaired iron wheel was operated until the new one could be made ready, and then, during one week's shutdown, the old wheel was removed and the new one installed without removing the main shaft from the engine.

It will be noticed from the accompanying illustration that the new wheel center, while being in only two pieces, has double faces to accept two sets of arms, as described. This center complete weighs not far from 10 tons in itself, while the 20 arms weigh about a ton apiece.

The work of removing the old wheel and installing the new one was carried on under pressure, so to speak, and in cramped quarters, and the accomplishment of the complete job in one week's time was considered quite remarkable. The wood rim was built onto the arms, piece by piece, at the mill, each piece being securely spiked and

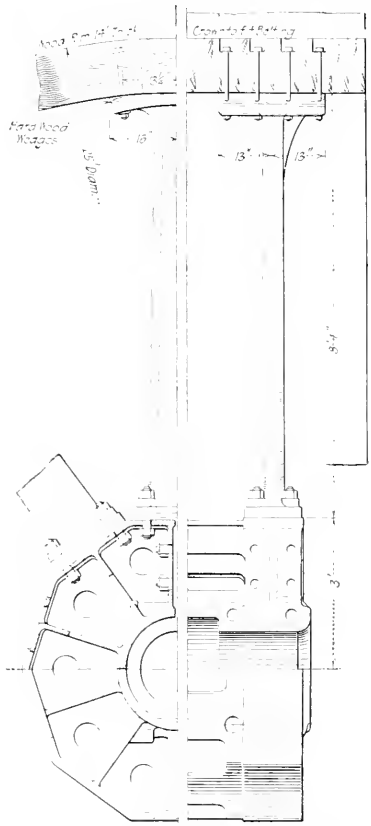


Fig. 2. Showing Construction of Large Wooden Flywheel

glued, and then the completed rim was turned up true and faced off with three independent crowns for as many belts of unequal width.

The builders of this wheel have installed a number of such wheels at various places throughout the country, and make a specialty of their design and construction. They have recently converted two 15-ft. by 25-in. iron wheels into one wheel of 16½ ft. diameter by 51 in. face, by building a wood rim onto the faces of the old iron wheels, giving them greater strength, permitting higher rotative speed than that for which they were designed, and allowing the operation of one belt where two had previously been employed, while the cost of converting the old wheels into one was much less than would have been the cost of a new iron wheel to accomplish the desired purpose, and the time required was really not so great as would have been needed if the old wheels had been removed and a cast-iron one substituted.

Just for Fun

[*More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.*]

In one of the mills of this city there are two 72-in. by 16-ft. return-tubular boilers carrying 110 lb. steam pressure. The average load is about 176 i.hp. The boilers are kept reasonably clean and oil is used for fuel. One of the mill owners thinks he needs more capacity for steam generation because the engineer reports that the shell of the boiler becomes almost white-hot. After turning off the oil it gradually cools down to a cherry-red. —*A. L. Harris, McPherson, Kan.*

A few years ago I read in an article, "To stop knocking give your valve more lead." Very simple, thought I, although it had been my belief that the knock was in the piston and not in the valve. Besides, I had always thought that babbitt metal was better than lead. However, being a believer in following directions to the last letter, I took the valve, valve rod, and eccentric off, melted out the babbitt and substituted lead. I was firm in my conviction that it would be impossible to give the valve more lead than that. The knock did not stop at all; the article, therefore, was wrong. Nevertheless, lead is necessary and it does stop knocking.—*W. F. Schaphorst, New York City.*

A prize "bone-head" trick was pulled off on a new Corliss engine built by one of our largest concerns and erected by one of their shop men, but evidently changed afterward. At any rate complaint was made that the engine would not carry the load, in fact would "lay down" with about quarter load. One of the best shop men was rushed to the scene, arriving just before noon. On entering the engine room the very first thing he noticed was that the eccentric connecting-rod was connected to the upper pin on the rocker and the reach-rod connected to the center pin—in other words the two rods were reversed in position. The motion being so reduced, the valves were not given sufficient opening, hence the lack of power.

Taking in the situation at a glance, the shop man suggested going to dinner before beginning the task of putting the engine right, to which the engineer agreed. They started out together, but the shop man suddenly remembered having left his gloves, told the engineer to go ahead and order the dinner and he would go back after them. While in the engine room alone, he quickly reversed the connections, then hastened to join the engineer in a good dinner and "trimmings." On their return to the engine room he suggested that the engine be started up so that he might judge of its ailment. It, of course, behaved all right; then he suggested putting on the load, and to the wonder of the engineer it carried it with ease. The engineer was kept guessing to the full satisfaction of the shop man before being told what had happened.

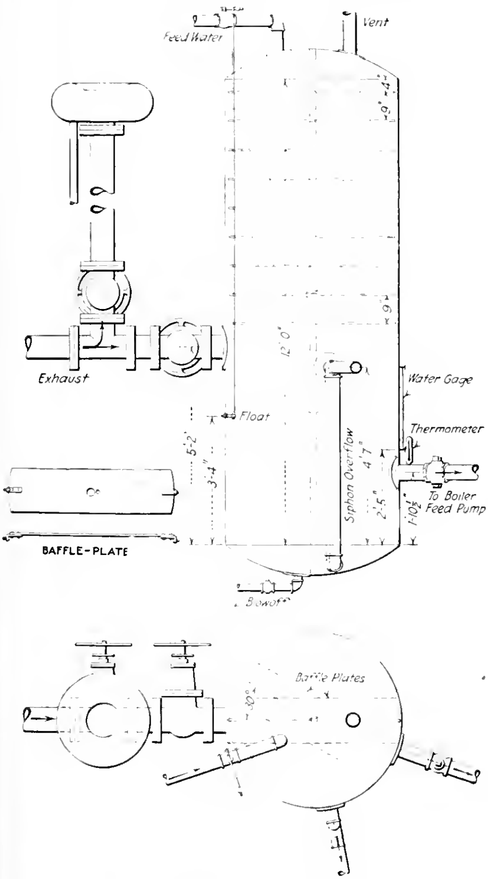
This is a "sure enough," "honest injun" true story.—*F. R. Compton, New York City.*

An Open Feed-Water Heater

By F. F. Jorgensen

The illustration is of a home-made open feed-water heater used at a coal-washing plant. It heats all of the feed water for four 150 (rated) horsepower boilers. Exhaust steam is taken from a 13x16-in. double engine, a 12x14-in. single engine, a 13x12-in. single engine, the boiler-feed pump and a small coal-drag engine.

Nearly 9000 lb. of exhaust steam per hour is available. The back pressure is but little above atmospheric,



Details of Heater Construction

so that if all the steam were condensed 970.4 B.t.u. per lb. of steam would be obtained, or 8,733,600 B.t.u. in all.

About 15,000 lb. of feed water per hour is required and its temperature on entering the heater is very little above 32 deg. during the cold weather. The temperature leaving the heater remains practically constant at 212 deg. In raising the temperature of the water from 32 to 212 deg., 180 B.t.u. per lb. is required.

The heater was made from a discarded compressed-air receiver and it has been in service for a year, giving excellent results.

Variation in Coal Constituents for Similar B.t.u. Values

By Henry D. Jackson

The recent and persistent agitation of the subject of purchasing coal on the B.t.u. basis is of value to both the buyer and the seller, but if coal were bought on the B.t.u. basis alone, it would be likely to prove an expensive method to the purchaser, for all coals having a high B.t.u. content are not necessarily good for use under the boilers of the plant for which the coal is being purchased.

Coal varies widely in ash, moisture, fixed carbon and volatile matter. The ash is, of course, a waste, and a low ash content is advisable because it means that less coal has to be fired and less waste material handled for a given evaporation. Moisture is a detriment because it must be evaporated and the heat to do this must come from the coal, and therefore, considerable moisture means a large waste of heat. Volatile matter may or may not be of value, depending upon what it consists of, as well as whether it can be burned to advantage under the boiler.

The table shows the range of constituents found in coals having the same B.t.u. value. Take the two top rows

TABLE SHOWING WIDE RANGE IN COAL CONSTITUENTS FOR APPROXIMATELY THE SAME B.T.U. VALUES

Value in B.t.u.	Moisture	Volatile Matter	Fixed Carbon	Ash
10,001	8.93	36.53	33.76	20.78
10,264	3.53	20.75	47.85	27.87
10,816	10.83	36.24	39.75	13.18
11,142	9.04	29.65	45.57	15.74
12,195	3.12	35.75	47.67	13.96
11,906	5.59	25.07	53.28	16.08
12,958	4.49	40.55	47.43	7.53
13,129	3.24	17.46	66.69	12.61
14,107	1.75	36.77	55.14	6.34
14,024	2.14	16.83	71.91	9.12

of figures, for instance; the moisture varies between 8.93 and 3.53 per cent., the volatile matter between 36.53 and 20.75; fixed carbon between 33.76 and 47.85, and the ash between 20.79 and 27.87, yet the B.t.u. content is practically the same.

For most boilers as set at the present time, the second coal shown on this list would probably be more satisfactory as regards evaporation than the first, although its ash content is higher. This is due to the higher fixed carbon and lower moisture. Following these figures right through, one can readily see that there is a wide variation in coals. Therefore, the buyer should take into account more than the B.t.u., and in order to be sure that the coal purchased is the best for the purpose, it is advisable to burn it under the boilers and to determine the evaporation, and then buy by specification that coal which gives the best evaporation for the lowest price. Test every car of coal and see that it comes up to specification. Put a bonus and forfeiture clause in the specification, which will give a bonus for an increase in the fixed carbon or decrease in the volatile, ash or moisture, and exact a forfeiture or a decrease in price for excess of ash, moisture, or volatile matter or decrease in fixed carbon, the object being to obtain a coal having a maximum of B.t.u. with a minimum of waste material. The specification should limit the minimum amount of fixed carbon as well as the maximum amount of ash and moisture acceptable.

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A New Organization called the Institute of Industry and Commerce has been formed in London. The institute hopes, among other things, to stimulate and encourage standardization in methods of production, organization and distribution, to bring about closer coöperation between science and management and labor in industry, and to consider all legislation which may affect industry.—Foreign Exchange.

Test of Turbo Air Pump

SYNOPSIS—A pump which apparently produces over 100 per cent. vacuum, the absolute pressure in the chamber being less than that of water vapor present at the observed temperature.

The editor was privileged to see recently, at the works of the Wheeler Condenser & Engineering Co. at Carteret, N. J., a turbo air pump under test. This pump is of the type in which the air is expelled by a succession of rapidly moving water pistons. Fig. 1 shows the action diagrammatically, the rotating impeller throwing off streams of water at a high velocity, which are broken up by the pointed divisions of the compression channels into plugs which continue their course through the channels, pushing the air and noncondensable vapors before them. The pump in this form was developed by the Allgemeine Elektricitäts Gesellschaft, the General Electric Co. of Germany, and is built by the Wheeler Condenser & Engineering Co. Fig. 2 shows the exterior of the impeller and the renewable entry piece at the commencement of the compression channels, and Fig. 3 the pump in section.

The pump under test had a capacity suitable for about a 20,000-kw. condenser. The purpose was to determine how nearly it would come to maintaining a theoretical vacuum when different amounts of air were allowed to enter. The pump was arranged for testing, as shown in Fig. 4. The plugs at *A A A* controlled carefully calibrated openings through which known amounts of air were admitted. The temperature of the incoming and outgoing hurling water was measured by the thermometers at *B* and *C*, respectively. The mercury column at *D* indicated the vacuum, and the V-notch weir *E* enabled the amount of hurling water used to be determined.

The temperature of the hurling water as measured by the thermometer at *B* was 93 deg. F., and one would naturally say that the absolute pressure in the chamber *F* could not be less than 1.556 in., the pressure of water vapor at 93 deg. As a fact, however, the mercury gage *D* connected with this chamber showed a vacuum of 28.8 in.

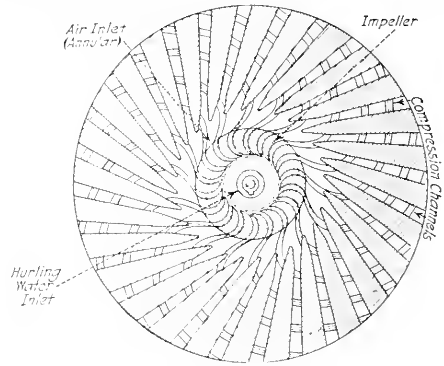


FIG. 1. DIAGRAMMATIC SECTION OF PUMP

The barometer at the time read 30.02 in. If these were right the absolute pressure in the chamber was 30.02 — 28.80 = 1.22 in., or only 0.784 of the tension of water vapor at 93 deg. with which it was supposed to be in con-

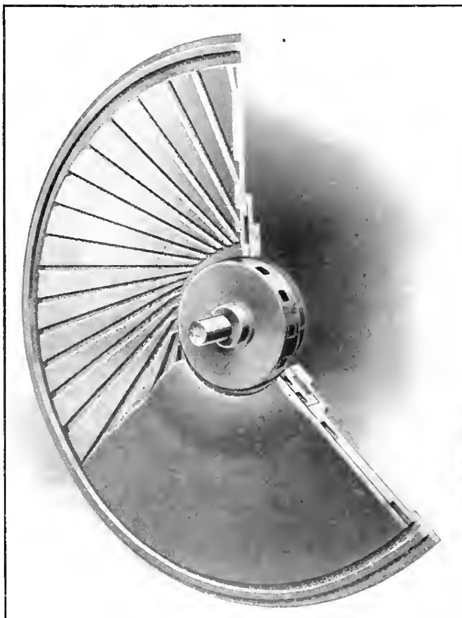


FIG. 2. IMPELLER AND COMPRESSION CHANNELS

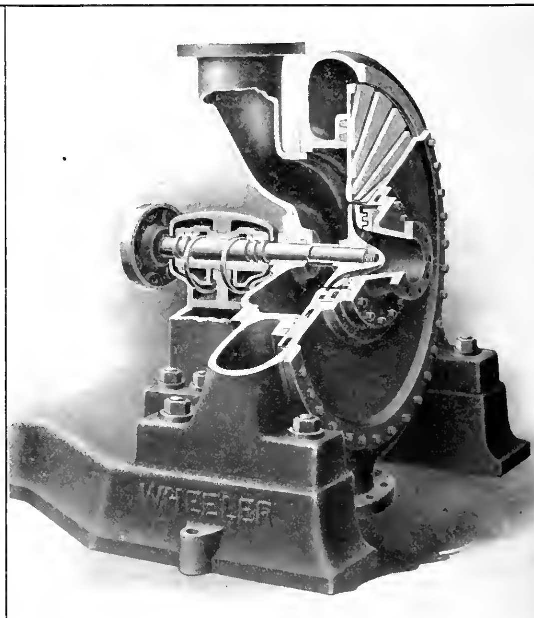


FIG. 3. SHOWING IMPELLER IN SECTION AND IN SITU

tact. It was not until just after the fourth observation, as shown in the fifth column of Table 1, when the air was being admitted at the rate of 32 cu.ft. per min., that the pressure in the air inlet became greater than that due to

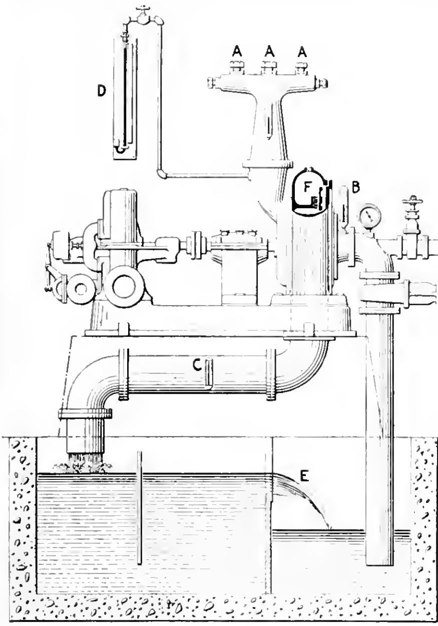


Fig. 4. Pump Arranged for Testing

the temperature of the hurling water. An explanation suggested by the engineers of the condenser company is, that as the water is subjected to the action of the vacuum a small amount evaporates under the reduced pressure and a cooling effect occurs, resulting in a lower temperature and vapor tension, or higher vacuum, in the immediate vicinity of the surface of the water.

It is customary at the Wheeler works to refer all vacuums to a 30-in. barometer. This is done in the sixth column of the table, and the ratio of the vacuums so found to the vacuum (28.144 in.) corresponding to the tension of aqueous vapor at 93 deg. and a 30-in. barometer is given in the eighth column. This ratio would, however, be different for each barometric pressure taken as a base.

In Table II are given the results of a test of a pump of the same type, but of relatively small size, connected to a surface condenser and with cooler water, the condenser working at about half of its rated capacity. Notice the close agreement between the exhaust-steam temperature corresponding to the vacuum (Col. 3) and as observed (Col. 4).

TABLE I

Barometer Reading In. Mer		Observed Vacuum In. Mer		Absolute Pressure at Air Inlet In. Mer.		Pressure of Aqueous Vapor at 93 Deg. F In. Mer.		Ratio of Condenser Pressure to Vapor Pressure at 93 Deg. F	Observed Vacuum Referred to 30-In Bar.		Vacuum Corresponding to Pressure of Aqueous Vapor at 93 Deg. F Referred to 30-In. Bar.		Ratio Observed Vacuum to Vacuum Corresponding to 93 Deg. F. Both Referred to 30-In. Bar.	Free Air, Cu.Ft per Min.
30.02	—	28.80	=	1.22	÷	1.556	=	0.784	28.78	÷	28.444	=	1.0118	0.0
30.02	—	28.77	=	1.25	÷	1.556	=	0.803	28.75	÷	28.444	=	1.0108	3.0
30.02	—	28.73	=	1.29	÷	1.556	=	0.829	28.71	÷	28.444	=	1.0094	8.7
30.02	—	28.60	=	1.42	÷	1.556	=	0.913	28.58	÷	28.444	=	1.0049	14.0
30.02	—	27.86	=	2.16	÷	1.556	=	1.388	27.84	÷	28.444	=	0.9788	32.0
30.02	—	27.10	=	2.92	÷	1.556	=	1.877	27.08	÷	28.444	=	0.9520	46.0
30.02	—	26.60	=	3.42	÷	1.556	=	2.198	26.58	÷	28.444	=	0.9345	57.0
30.02	—	24.90	=	5.12	÷	1.556	=	3.290	24.88	÷	28.444	=	0.8747	89.0
30.02	—	24.05	=	5.97	÷	1.556	=	3.837	24.03	÷	28.444	=	0.8448	108.0
30.02	—	21.75	=	8.27	÷	1.556	=	5.315	21.73	÷	28.444	=	0.7640	165.0
30.02	—	20.00	=	10.02	÷	1.556	=	6.440	19.98	÷	28.444	=	0.6024	222.7

Steam Piping

While the work of planning and erecting steam piping seems of minor importance, its proper execution affects the economy and continuity of the plant's operation to a greater degree than an equivalent expenditure on any other feature of the average power plant. The factor of safety usually employed for pipes and fittings is from six to ten times the working pressure they are intended for, yet constant annoyance and even disaster follow their improper erection or later neglect. Among the chief causes of failures of pipe systems are water-hammer, expansion and contraction, which produce distortion, vibration, misalignment, poor workmanship at joints, and corrosion.

Water-hammer may be produced by a great variety of

TABLE II

Time	Vacuum Referred to a 30-In Bar	Temp. Corresponding	Temp. of Exhaust by Thermometer	Temp Hurling Water In	Temp Hurling Water Out	Temp. Circulating Water In	Temp. Circulating Water Out	Temp Condensate
12:30	29.64	50	50	37	39	37	44	46
1:	29.64	50	52	38	40	38	43	47
1:30	29.59	53.5	54	38	40	38	44	48
2:	29.59	53.5	54	38	40	38	44	48
2:30	29.59	53.5	54	38	40	38	44	48
3:	29.54	56.5	58	37	40	37	46	46
3:30	29.79	53.5	54	37	40	37	46	47
4	29.64	50	52	36	38	36	44	45

conditions, some of which are difficult to forestall or identify, but the effect is usually the same—broken fittings or at least loosened joints, resulting in more or less serious damage. Any depression, or pocket, below the drainage level of the pipe line may, under certain conditions, accumulate condensate or water enough to produce water-hammer, therefore such pockets should be avoided. A valve so placed that water may accumulate above it when closed, constitutes one of the most frequent sources of water-hammer. When such a location is unavoidable a drain should be tapped in immediately above the valve, with the small drain valve easily accessible to the operator when at the main valve. A short open-end drain pipe is usually best, so that the operator may be sure the drain is not obstructed and that the steam is reasonably free from moisture, before opening the main valve. This is intended to be independent of and in addition to the regular drainage system. Reducing tittings on horizontal runs are frequently responsible for water pockets. Owing to the rapid rate of condensation, water-hammer may occur if steam is too rapidly turned on long lines when cold, even though sufficiently graded and drained for ordinary duty. It should be borne in mind that disastrous water-hammer may occur at low pressure—even below that of the atmosphere.

Expansion and contraction, when no adequate allowance has been made to relieve the strain so produced, always tend to loosen joints and often distort valves and cause fittings to break. Allowance should be made for elongation with an increase of temperature to which the pipe is subjected, equal to the difference in degrees multiplied by the length in inches and divided by the constant 150,000, or 0.6 in. for each 100 deg. per 100 ft. of pipe. The most commonly used form of expansion absorber is the ordinary, long-radius bent pipe. So called swing joints are also used, consisting of screw fittings so placed that expansion or contraction will cause them to change their relative positions by turning on the thread. Two pairs of elbows connected by short lengths of pipe are usually necessary. The threads for such work should be well formed and ground in with emery and oil to make as perfect a ground joint as possible, and after wiping off the emery they should be well lubricated and not made up too tightly. The extra resistance to the flow of steam caused by the elbows is an objectionable feature in addition to the difficulty of maintaining a steam-tight joint. The slip joint, consisting of a sleeve, smooth and true, attached to one section of the pipe and sliding in a stuffing-box attached to the other section, is quite commonly used and has advantages and uses peculiar to itself. Another form is made of a pair of large circular flexible diaphragms of steel, copper or other metal bolted to the flanges of the two sections of pipe and bolted together at their periphery with a flange of large diameter between. This forms an expansion joint of considerable merit. A corrugated copper sleeve, with supporting rings and having a flange attached at each end, is used where the expansion is not too great. Care should be taken not to tax this joint beyond the limits recommended by the manufacturer. Ball-and-socket joints and sometimes unions are utilized to avoid excessive expansion strains.

Vibration is usually caused by motion of the engine or other machinery to which the pipe is attached and the pulsating of the steam in the pipe. If this motion, or vibration, is rapid and violent the life of the pipe line will be uncertain. In cases where there are several high-speed engines which cause the pipes to vibrate in unison part of the time and out of step at other times, the strain becomes particularly severe at intervals. Lines should be free to expand lengthwise, but their motion in other directions should be carefully limited.

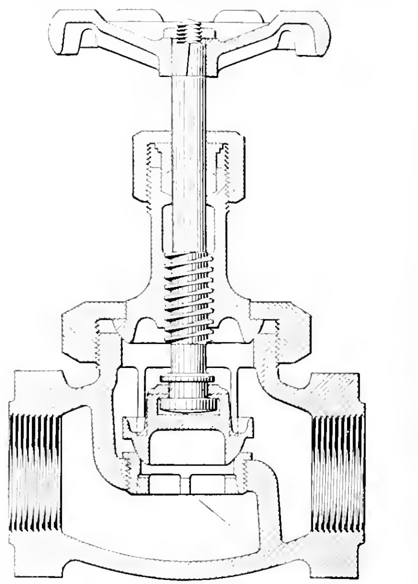
Misalignment puts severe strain on the pipe and fittings, either in connection with expansion and contraction or independently. If the pipe line is not straight, because of crooked threads or flanges, the difficulty will usually increase under heat changes, although joints that have to be forced out of their natural positions or strained when cold may sometimes take an easier position when heated; but such strain should be carefully avoided.

Poor workmanship will soon manifest itself when the pipe system is subjected to the foregoing conditions in addition to the pressure sustained. Work poorly done through carelessness or ignorance is scarcely less criminal than if so done with intent to do injury. Ignorance is no excuse and carelessness is less than none—it is a confession.

External corrosion is sometimes serious when a combination of heat and moisture is augmented by a trace of acid or other corrosive element in the pipe covering. This condition is more frequently met with in underground construction where, incidentally, it is the more serious on account of the inaccessibility of the line. It can usually be avoided by a protective coating applied to the pipe before the insulating covering is put on. Internal corrosion is more common in boiler-feed lines and return lines from steam-heating systems and is sometimes due to the action of warm distilled or nearly chemically pure water, which readily attacks wrought iron or steel. Water not over 80 per cent. pure is not likely to attack the piping seriously, but if air is admitted with warm water containing a trace of acid there is likely to be corrosion. Cast-iron or brass pipe will usually withstand indefinitely the action of water fit for boiler feed.

Powell "Irenew" Valve

The Powell "Irenew" valve, a sectional view of which is shown, has recently been developed by the William Powell Co., Cincinnati, Ohio. The main feature is the removable horseshoe disk, which is arranged to slide over the head of the stem into a socket, thus permitting it to swivel freely. When it is desired to remove the disk from the stem for regrinding or renewing, it is merely slipped from the socket. Should it become needful to regrind the valve, it is not necessary to disconnect it from the pipe, but by simply releasing the bonnet and unscrewing the large hexagonal nut the valve bonnet may be withdrawn and a pin fitted through a hole in the valve-stem head to lock the disk.



"Irenew" Valve in Section

The removable disk is made of a noncorrosive metal applicable to most temperatures of superheated steam. To remove the seat, a screwdriver or other flat tool is used, which engages with the lug projecting from the inner circle; the seat is screwed out of the valve and a new one inserted.

Municipal Plant Lowers Rate—The City Council of Two Harbors, Minn., has ordered the rate charged by the municipal lighting plant reduced to 6c. per kw.-hr. for lighting instead of 8c., as heretofore, and a new rate of 3c. per kw.-hr. for power. Consumers who take the power rate will be obliged to install a separate meter. The municipal power plant is a paying proposition, and the city officials feel that they can afford to make the reduction in rates.

Editorials

Depreciation as a Practical Problem

To many engineers the word depreciation visualizes difficult and wearisome arguments upon the present and past values of power-plant equipment by theorists before commissions passing upon the right of corporations to issue more stock, maintain existing prices for service, or consolidate with others of their kind. To others depreciation means the underlying reason why the company had to buy a new condenser or feed pump last week, after getting a good many years of satisfactory service out of the equipment. To still others it means the cause of getting eight hundred dollars for a compound engine in perfectly workable condition, which cost originally six thousand dollars, but which has been obliged to make way for a turbo-unit that will generate more horsepower-hours per cubic foot of space in a day than the faithful old cross-compound could produce in a fortnight.

In technical literature there is hardly a subject on which more purely speculative matter has been written than on depreciation. Hundreds of pages in court and commission cases have been devoted to mere definitions of the word, and assumptions by the thousands have been made and will be made as to values and percentages to be allowed for depreciation in one form or another, in trying to prove some administrative policy just or some existing set of charges proper. Probably depreciation will never be reduced to a plain "two-and-two-make-four" basis while progress continues in equipment and plant design, but men closely associated with such plant and equipment can do much toward ridding the subject of some of its most glaring uncertainties if they attack the problem systematically and are accorded the coöperation of their employers.

Depreciation is, finally, a matter of plant life. How it shall be offset is a problem for the statisticians, but the basis upon which the men behind the gratings and wired-glass windows are to proceed has a direct and inescapable origin in the work of the engineer. How little we really know about this life question and how much we assume! Surely, it is time for the engineer to begin to contribute his observations and judgment in a broader way upon this important problem, which is always the unknown coefficient of the manager's equation of probable cost. Where can the engineer lay hold of the matter effectively enough to help his employer, to add some specific solvent to the mass of undigested and hypothetical data which is congesting the modern industrial library?

There is only one way to go about this task and that is by keeping a record of the installation, repairs, replacements, failures, and final disposition of every piece of apparatus affecting an estimate of the probable life of similar equipment at any future time; of studying the influence of performance and of idleness upon wear and tear and upon fitness for the service of today and of day after tomorrow; and by maintaining sufficiently complete records to enable the owner of the apparatus at practically any time to determine with least delay the total outlay of money upon it to date compared with the initial cost. It is not too late to begin to collect such material in many plants where the original equipment still handles the daily service. Every time a piece of machinery goes into commission fresh from the factory, the operating engineer should be permitted to acquaint himself, if he will, with its initial cost in as much detail as necessary; and the dates on which spare parts are substituted, with the cost of so doing, should be set down as part of a definite record which will enable the expert ultimately to judge the probable life of such equipment without guessing.

True, the mere cost of repairs and spare parts inserted may not throw light on the life of a machine as a whole, but here is exactly where definite data are useful in marking off life zones which will at least indicate where money must be spent to make good the aging of equipment and where enough durability can be anticipated to reduce the annual sinking-fund allowances for final replacement. There has been too much temptation in the past to assume all-around depreciation rates on aggregations of apparatus having enormous differences in life—a policy justified by the need of doing something constructive to establish a fund capable ultimately of putting in the equivalent in capacity of the depreciated equipment, but none the less a policy which must sooner or later give way to the more scientific plan of basing life and total cost estimates on data gathered in plant and field. There is room for real research in this department of engineering economy.

Placing the Blame

If there is complaint that water powers in the public domain in the West are being withheld from use, the blame must rest with the men and interests responsible for the legislative methods which made impossible the passage of the Adamson and the Ferris bills, urged by the Secretary of the Interior, approved by the President, and indorsed by the leading conservationists of the country. Under cover of specious arguments for states' rights, filibusters on buffer bills, and senatorial courtesy, the same senators and the same interests which defeated water-power legislation seven years ago have again made it impossible this year.

The remaining water-power sites in the public domain are of enormous value, controlling as they do the key to the development and use of the vast water powers in Western cañons and streams. Many other valuable power sites once owned by the nation have been acquired by speculative and monopolistic private interests in the past for little or no return to the Government, and have been capitalized at large values on which power users have been required to pay interest in the form of power rates. Other sites are being held unused by private owners who paid nothing, or next to nothing, for them, in anticipation of the needs of communities not yet developed, or for the purpose of maintaining rates for power supplied from plants already in operation. While independent interests concerned in hydro-electric development have generally expressed willingness to accept the terms of the bills before the late Congress, some of the larger and politically more influential interests refused even to consider the terms.

President Roosevelt withdrew the power sites which continue in the ownership of the people to prevent them from being gobbled up by the water-power trust. The "interests" at that time were powerful enough in Congress to prevent enactment of legislation that would allow use of these withdrawn sites under government control and with limited terms of occupancy and use. These same interests have so far blocked and defeated the efforts of the present Administration to secure legislation of the same nature. It is apparent that their purpose is to tire out the Government, in the hope that eventually these valuable sites may be given away, as have others in the past. It so happens, however, that the nation is fairly well informed nowadays of the value of these remaining national assets, and there is little probability of public opinion ever agreeing to turn them over as a free gift to any individuals. Fortunately for the country, delay in water-power legislation means nothing worse than delay in development. It is a big stake for which the trust is playing, but it has a forlorn hope of winning, and the longer obstructionists block legislation that would make regulated development possible, the stronger the growing sentiment for public development and operation is likely to become.

Efficiency Engineering

Many engineers are beginning to see a lucrative field in applying the principles of efficiency to engineering, particularly to factory power plants. Many have already gained considerable success, which has tempted others to follow their lead.

Efficiency applied to power plants means actually the elimination of wastes, these wastes being usually the result of faulty engineering when the plants were designed. The owner of an inefficient plant is often the victim of an inefficient or an unfit engineer. This is a reflection on both the owner and the profession.

No engineer worthy of the name is really anything else than an efficiency engineer; his whole course of study and practice is to adapt nature's law to practical needs economically. No standard textbook teaches us to design otherwise than economically. The laws relating to the transformation of heat energy have been known for years. The heating of feed water, economical sizes and covering of steam piping, the heating value of exhaust steam, etc., are not new. Certain refinements in the apparatus used in power work have been made, and special equipment has been devised, much of which enables improvements to be made, looking to the saving of both labor and coal. At the same time, many of the new appliances are got up to sell. The uninitiated owner frequently falls for the expert salesmanship employed to sell these devices. Some salesmen call themselves, and really believe they are, efficiency engineers, owing, no doubt, to the ease with which they are able to dispose of their goods. This practice has given the engineer considerable trouble in the work he is now undertaking, as owners and superintendents have become somewhat skeptical.

The engineer who often meets with scant tolerance at the hands of the owners also has himself to blame, outside of the bad effect caused by the exploiting of bad appliances. Looking at the matter a little deeper, we find that almost anybody can hang out his shingle and practice engineering. If plausible enough, he can and does secure work which afterward needs considerable attention and expense to make it perform economically. Then again, there is almost a department-store variety of competition among some engineers, in price cutting, resulting in the job being a repetition of this practice.

We are inclined to believe that these methods have called attention to the need for the efficiency engineer far more than the so called recent discovery of efficiency, or the availability of new apparatus to secure economy, the principles of which are old and well understood.

Other professions, such as the medical and legal, require their members to pass examinations and meet certain requirements before permission is given them to practice. The profession of engineering, although really the oldest of them all, puts no restrictions on its followers. Would it not be best for all concerned if consulting as well as operating engineers were prohibited from practicing without a license?

Skepticism as an Asset

Orthodoxy has little place in science. Skepticism—the insistent desire to be "shown," unwillingness to take things for granted—is a real asset to the engineer. It makes him uncomfortable enough, as everyone knows, but it helps him master his profession and makes him of increasing value to his employer.

It is unsafe to assume that a thing cannot be done merely because someone says so. Reports that a certain policy or practice is impossible must be checked before they are accepted. Suppose, in a large plant, a subordinate engineer investigates heat losses in certain piping and reports that nothing further can be done to remedy the situation. If the chief accepts such a report without checking its reasoning and conclusions, is he much better than a rubber stamp?

Coöperation and dependence upon the work of others are absolutely necessary today in engineering as well as in commercial activities, but a certain class of problems needs to be handled by direct methods, with routine thrown out of the window. All jobs which look impossible are of this class. Plenty of them *are* impossible, financially or physically, but the point is not to make any assumptions. If it is a report to the "boss," let it carry the convincing facts and arguments, so that it can be checked at the first reading. If it is a job handed down to the engineer from his superiors, let it be analyzed from every possible viewpoint before the answer is sent back that it is not feasible to carry out the plan.

These are more than generalities. They fit into daily experience. They teach that merely glancing over a report or a drawing and putting on the "O.K." with one's initials without a real check of the work, is largely wasted energy, economically unjustified. Question every proposition; make it prove its right to live; and by so doing cultivate the true scientific spirit which, combined with a sense of financial proportion, keeps the engineer high among the intellectual and constructive workers of the world.

Correspondence

Relative Water Required by Refrigerating Systems

Referring to G. B.'s question, page 311, Mar. 2 issue, I should judge that he wished to know the difference in quantity of water required for cooling, regardless of the kind of prime mover used. If both systems were motor-driven the absorption system would require three times the amount required for a compression system of equal capacity.

The quantity of water needed in the ammonia condenser would be the same in either system. To overcome the heat of absorption we need about twice the amount required in the condenser, making about three times the quantity for the absorption system that is needed when the compression system is used. When the strong-liquor pump to the absorption system is steam-driven its exhaust and other exhaust steam available can be used in the ammonia still, the condensate from the still can be returned to the boilers, and makeup water for the boilers can be taken from the water that has passed the condenser in either system.

In small absorption systems where closed ammonia condensers are used, it is usual to pipe the discharge from the condenser through the cooling coils in the absorber. When this is done there will be a slight rise in the temperature of the water after passing the condenser, but there will be a rise of about 30 deg. F. after leaving the absorption cooling coil. I have used this water to advantage in supplying a hot-water boiler when there was a demand for hot water about the place.

C. E. Bascom.

Westfield, Mass.

Boilers for Isolated Plants

The following criticism is directed at errors, as they appear to the writer, in C. L. Hubbard's article on "Boilers for Isolated Plants" in the Feb. 16 issue.

1. About the middle of the first column, page 233, we read: "The heat absorbed by the water in the boiler per pound of coal burned =

$$\frac{970.4 \times W \times q \times f}{w}$$

where

W = Apparent weight of water evaporated in pounds per hour.
q = Quality of the steam.
f = Factor of evaporation.
w = Weight of coal burned, in pounds per hour.

It is theoretically incorrect to introduce the quality of the steam into the computations at this point. It should have been taken into account in figuring the factor of evaporation.

The total heat of dry saturated steam is made up of two parts, the sensible heat of the liquid and the latent heat of vaporization. If we are dealing with wet steam of quality q, we have for its heat content all of the heat of the liquid plus q per cent. of the latent heat of vaporization. Obviously, it is incorrect to take q per cent. of the sum of both parts when we should have used one part in its entirety and q per cent. of the other part.

2. Near the bottom of the same page, is stated: "W.R. = Water rate of the engine under given conditions of *feed-water temperature and* steam pressure . . . ." The steam consumption of the engine is independent of the feed-water temperature and the words in italics should be omitted.

3. The last sentence of the article, near the top of page 234 reads: "All heating requirements are reduced to pounds of steam per hour and the result divided by 34.5 to find the boiler horsepower." This should read: "the result multiplied by the factor of evaporation and divided by 34.5 to obtain the boiler horsepower."

T. B. Hyde.

Lakewood, Ohio.

Calculating Pump Slippage

The letter on the subject of calculating pump slippage, by George L. Sullivan in the Dec. 29, 1914, issue, page 928, indicates a practical, though somewhat inaccurate way of determining pump slippage.

The slippage of a pump depends not only on the amount of the fluid slipping by the piston, but a great deal of it is due to the fluid running back before the valves close. Therefore, at medium speeds, the cylinder is not quite filled to its capacity at each stroke of the piston. Thus, it is evident that unless the slippage is determined by a calibrated flow meter, or by weighing the water, the result will be inaccurate.

For small and medium-sized pumps it is practical to connect a number of barrels or other receptacles in series, so that by connecting the discharge with one of the barrels, the water will run over and flow into the next barrel.

Knowing the capacity of the barrels, the slippage may be determined by subtracting the number of gallons of water in the barrels from the theoretical capacity of the pump, or,

$$S = \frac{aln}{231} - Q$$

where

S = Pump slippage;
Q = Quantity of water in the barrels in gallons;
a = Area of the cylinder in square inches;
l = Length of stroke in inches;
n = Number of discharge or working strokes required to fill the barrels.

The pump should be allowed to make a few strokes before discharging into the barrels. Care should be taken to get the pump up to the normal working speed and pressure as soon as possible.

For large pumps this method is not practical, as the barrels will be filled too quickly.

Providence, R. I. Samuel L. Robinson.

Auxiliary Exhaust Valves on Uniflow Engines

The writer, having read the article by Professor Stumpf in the Mar. 23 issue of POWER, entitled "Recent Development in the Construction of the Uniflow Engine," must take issue with the author on several points, especially the paragraph reading as follows:

> It is wrong in principle to build uniflow engines for condensing service with auxiliary exhaust valves. The short compression is wrong, and just as wrong is the increase of clearance space and surface connected with these valves. Even when used for noncondensing service with steam pressures as used in modern power plants, auxiliary exhaust valves show no gain

The reason for the adoption of the auxiliary exhaust valve, as applied to uniflow engines by the Skinner Engine Co., is to allow them to be operated noncondensing without the addition of wasteful clearance spaces which would otherwise be indispensable. It will be of interest to the reader to learn what these valves accomplish.

When the engine is running condensing, these valves are not in operation; but their function on a condensing engine is to relieve the cylinder of dangerous compression if the vacuum should suddenly break. In this event they operate automatically, and the engine continues to run noncondensing and with high economy.

The reader will understand that, with compression extending during 90 per cent. of the stroke and with atmospheric pressure in the cylinder at commencement, as would be the case in a uniflow engine without auxiliary exhaust valves, operating noncondensing, the compression would become so great as to endanger the cylinder. The greatest prejudice against the uniflow engine that European builders have had to overcome was the fact that so many cylinders had been cracked through the central exhaust ports, owing to this excessive compression when the vacuum broke

Two cylinders were thus wrecked at the plant of Vivian & Sons, Hafod Copper Works, Swansea. South Wales; and many other wrecks in Europe have been reported. The writer's understanding is that several cracked cylinders have occurred in this country on condensing uniflow engines not equipped with the auxiliary exhaust valves. Such accidents prove that cylinder relief valves cannot effectually relieve this compression; and in no case that has come under the writer's observation did the compression lift the steam valves a sufficient amount to relieve the cylinder of the excessive pressure.

The clearance volume required for these auxiliary exhaust valves is less than 1 per cent., even on small engines, and about ½ per cent. on large engines. Therefore, the uneconomical effect of these clearances is negligible.

The last statement in the paragraph quoted, "Even when used for noncondensing service with steam pressures as used in modern power plants, auxiliary exhaust valves show no gain," is incorrect.

The professor condemns the use of auxiliary exhaust valves, on account of an increase in the clearance of less than 1 per cent. which is made necessary by their employment, when, if they are eliminated on a noncondensing engine, it is necessary to employ a clearance space amounting to 14.2 per cent. for an engine operating under 120 lb. steam pressure at throttle, with atmospheric exhaust, and 17.3 per cent. if the back pressure at the cylinder is 3 lb. above atmosphere. Still greater clearance must be allowed if superheat is added or if the boiler pressure is lowered.

There are two methods of obtaining this clearance—one by employing separate clearance pockets arranged to be placed in communication with the cylinder when the engine is operating noncondensing, as shown in Fig. 1, and the other by concaving the ends of the trunk piston.

The former method is especially disadvantageous on account of the large additional surfaces introduced. In fact, published economy curves of noncondensing uniflow engines having these clearance pockets show that they are not as economical as many counterflow engines

By the second method, besides having the handicap of additional clearance, the engine cannot be operated condensing with even fair economy without substituting a flush piston and thereby reducing the clearance.

With either method the clearance volume is fixed for noncondensing operation and, in an existing engine, cannot be varied to suit the changes of steam pressures, steam temperatures or exhaust pressures.

Fig. 2 is a noncondensing indicator diagram from a cylinder of the construction shown in Fig. 1. The amount of clearance required for noncondensing operation with a predetermined steam pressure is shown at the left, in proportion to the stroke of the engine.

That Professor Stumpf realizes this point is proven by the following excerpts from his well known work "The Una-Flow Steam-Engine." Speaking of the uniflow cylinder as applied to locomotive practice, where his own curves show that for a boiler pressure of 242 lb. (which is, of course, much greater than is employed in stationary plants) a clearance of 8 per cent. must be employed for saturated steam and 10 per cent. for superheated steam, and where for 154 lb. pressure he admits that 13.2 per

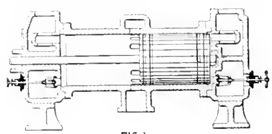


FIG 1

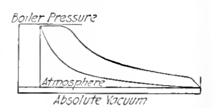


FIG.2

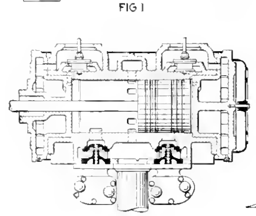


FIG 3

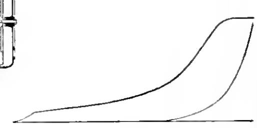


FIG.4

cent. clearance must be employed for saturated steam and 16.1 per cent. for superheated steam—all on the basis of atmospheric exhaust—he says:

> 1. The volume of clearance space should be kept as small as possible.
> 2. The amount of clearance losses depends upon the volume of the clearance.
> 3. The volume of clearance space is dependent upon the pressure and temperature of admission steam.
> 4. In all cases the pressure at the end of compression must not exceed the initial pressure.
> 5. Possible lines of development would be to employ saturated steam, introduced into the cylinder in as dry a state as possible, and superheated only a few degrees, and at a pressure that is at present usual in compound locomotives, so that the clearance space and the loss entailed thereby may be reduced.

In other words, he practically condemns superheat for noncondensing uniflow locomotives, because it makes necessary still greater clearance. The reader should bear in mind the fact that the pressures carried in modern locomotives are much higher than those employed in stationary plants, and that the clearance, therefore, may be less, but the professor wishes to reduce this clearance still further by employing saturated steam.

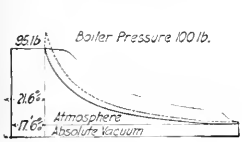


FIG 5

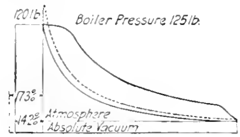


FIG. 6

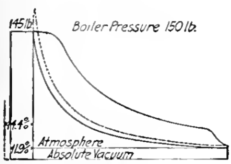


FIG 7

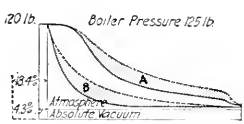


FIG 8

6. Other means for improving the action of the uniflow engine for locomotive work are to increase the boiler pressures and, consequently, the compression, so that the clearance volume may be reduced.

In other words, pressures from 235 to 260 lb. are not high enough for the economical operation of a large-clearance noncondensing uniflow engine.

7. Comparative tests with uniflow and counterflow engines, working with superheated steam of 11 atmospheres (161 lb. gage), have shown that the advantage rests with the uniflow engine for light and medium loads, but for heavy and overloads the advantage rests with the counterflow engine.

Here he admits that the large-clearance two-valve uniflow engine is not as economical on heavy loads as the counterflow type. Such is not the case with the small-clearance Universal Unaflow engine employing auxiliary exhaust valves which require the small clearance of less than 1 per cent. which Professor Stumpf objects to, as is proven by the reproduced performance curve of a Universal Unaflow engine operating noncondensing, with saturated steam at 136 lb. initial pressure.

Fig. 3 shows the Universal Unaflow construction, with auxiliary exhaust valves, which have the effect of delaying the compression to that point where it is usual to start the compression in a noncondensing counterflow engine. This construction allows the use of small clearances, even when operating noncondensing, which is not practical with the two-valve uniflow engine. Fig. 4 shows the diagram which it makes.

As a further proof that Professor Stumpf realizes the disadvantages of large clearances, it is only necessary to call attention to the fact that he sought to employ small clearance in a uniflow engine when operating noncondensing, by providing an auxiliary exhaust valve in the piston, which had the effect of delaying the compression beyond the point where the piston covered the central exhaust ports.

The European uniflow engine is, primarily, a condensing engine, for the reason that except in isolated cases all power plants in Europe operate with vacuum. In America, however, the great majority of plants operate noncondensing, and it is due to this fact that the necessity of adapting the uniflow engine to noncondensing work, which meant the employment of auxiliary exhaust valves to delay the compression, appealed to American engine builders before it was seriously considered abroad.

This principle, however, has now been adopted by a prominent German builder, and a description of this engine has been published in the European mechanical press.

One American builder, after having built and thoroughly tested a noncondensing uniflow engine having no auxiliary exhaust valves, now refuses to bid on the uniflow engine for noncondensing service.

The Skinner Engine Co., to determine the relative values of the two types under discussion, has made elaborate tests on both, having built a two-valve uniflow engine for this purpose. The results of these tests were greatly in favor of the engine with the auxiliary exhaust valves, especially when the steam pressure was changed from that for which the clearance in the two-valve uniflow engine was designed.

It was also demonstrated that the capacity of the cylinder was reduced owing to the long duration of compression, namely, 90 per cent. of the stroke; and this reduction of cylinder capacity compelled the employment of a larger cylinder. This in turn would impose greater stresses on the engine and decrease its mechanical efficiency.

The Universal Unaflow engine, which has auxiliary exhaust valves, has obtained mechanical efficiencies in excess of 97.5 per cent., proving the correctness of the principle from a mechanical standpoint.

Professor Stumpf has admitted that, with a noncondensing uniflow engine having no auxiliary exhaust valves, the volume of clearance is dependent upon the steam and exhaust pressures, and that it should be greater for superheated than for saturated steam.

Figs. 5, 6 and 7 show the different clearances required for two-valve large-clearance uniflow engines operating noncondensing, under different steam- and exhaust-pressure conditions. The full vertical line at the left of the diagram indicates the amount of clearance required in proportion to the stroke for different pressures of saturated steam. The dotted vertical line at the left shows the additional clearance required if the engine is to operate against 3 lb. back pressure above atmosphere.

In many plants the steam pressure fluctuates considerably and heating requirements render it advisable to employ a greater back pressure on a noncondensing engine during the cold months; and, inasmuch as it is impossible to vary the clearance in an existing two-valve noncondensing uniflow engine for the changes in steam and exhaust pressures, the engine is not as flexible or as efficient under these variable conditions as one employing auxiliary exhaust valves in connection with small cylinder clearances.

Fig. 8 is a double indicator diagram of a noncondensing Universal Unaflow engine (full line), superimposed on the diagram (dotted line) from a large-clearance uniflow engine having no auxiliary exhaust valves, both engines exhausting against a slight back pressure. The Universal Unaflow engine has 4.3 per cent. clearance, whereas the large-clearance uniflow engine must have 18.4 per cent. clearance for saturated steam.

With the large-clearance uniflow engine, the shaded section *A* must be added to the diagram to offset the loss in area *B* caused by early compression. This loss in area is compensated for only by the addition of more steam, a later cutoff, a higher release and less expansion.

The writer, however, readily agrees with Professor Stumpf on one point, namely, the necessity for the employment of steam-tight valves. Valve leakage in a noncondensing two-valve uniflow engine would be of more serious consequence than with a noncondensing uniflow engine having auxiliary exhaust ports located between the ends of the cylinder and the central exhaust ports, for the reason that the effect of this valve leakage would be in evidence during 90 per cent. of the compression stroke, and such effect would be to increase greatly the final compression pressure. With the same amount of valve leakage on a uniflow engine having auxiliary exhaust valves, the effect of leakage operates to increase compression during only 25 or 30 per cent. of the stroke.

Nevertheless, it is well to eliminate even this valve leakage, and this has been accomplished in the case of the Universal Unaflow engine by the adoption of a self-expanding poppet valve.

A. D. Skinner.

Erie, Penn.

Convex and Concave Drum Heads

The discussions during the past year in Power, with regard to the allowable pressure on convex drum heads, were of a purely technical nature, in which the aim was to discover the proper factor of safety, having in view explosions due to failure of convex heads near the root of the flange, by the tearing out of a circular section. It was pointed out by one writer that the factor of safety, 5, assumed in all rules in this country was entirely too low and that a higher factor, at least 8.33, should be used. F. G. Gasche, in discussing the subject advocated a factor of safety of 15.2, based on a thorough analysis of the stresses set up on such heads. Since that time another disastrous failure has occurred, resulting in heavy property damages and personal injuries, that also adds to the proofs of the fallacy of the factor of safety of 5.

In this connection I would mention recent tests to destruction of two concave heads that failed under hydrostatic tests. The vessels were tanks or drums, having the following dimensions: Diameter, 114 in.; shell plate, 1 in.; long seams, butt, double-strapped, triple-riveted, with an efficiency of 80 per cent.; tensile strength of heads and shell, 55,000 lb.; thickness of heads, 1⅛ in.; heads bumped to 114-in. radius and single-riveted to the shell. The required pressure was 150 lb., which gave a factor of safety of 5 in the shell. The sketch shows how the heads were put in, one being concave and the other convex. The heads were from the same block, being duplicates in each case. Moreover, the drums were new and were tested where built.

The first drum failed at about 210 lb., the failure occurring in the B head near the flange and also by tearing the shell near the head seam. The second drum failed by two ruptures in the head, the shell developing no defects, but the failure took place at 150 lb.

Commenting on this, I am of the opinion that the head in the first tank was harder or stiffer than in the second, inasmuch as the shell was injured. In other words, in the second case the head sprung in the center enough to cause it to rupture at a point relatively near the flange, and in the first one the head was strong enough to force a rupture in the shell adjacent to the head.

It seems to the writer that tests to destruction must be accepted as conclusive practical results on which to base deductions to determine the safe working pressure. To this end let us compare the results with the present rule as follows:

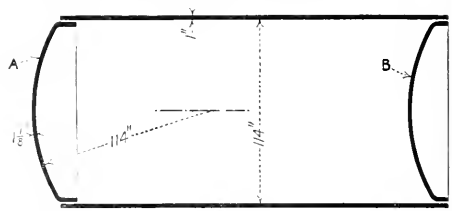
P = Working pressure allowed;
t = Thickness;
$T.S.$ = Tensile strength;
R = Radius, or ½ diameter of drum;
5 = Factor of safety.

Then

$$P = \frac{t \times T.S.}{R \times 5} = \frac{1\frac{1}{8} \times 55{,}000}{57 \times 5} = 217 \text{ lb.}$$

as respects the A head, and 0.6 of this, or 130 lb. on B. Using the factor 8.33, the pressure allowed on A would be 130 lb., and on B, 79.8 lb. This gives a real factor of about 2, based on the 150 lb. at which failure occurred.

By Mr. Gasche's factor, A would be allowed 71.4 lb. and B 42.8 lb., making the real factor about 3 on the concave head. In all the above calculations the tensile strength is taken at 55,000 lb. per sq.in.



Section through Drum That Was Tested to Failure

Granted a test to destruction is accepted as a practical method in determining the safe allowable pressure, and assuming that there should be a factor of 5 to safeguard against accident during the presumed life of a vessel, then the pressure allowed would be one-fifth the bursting pressure, or 30 lb.; as regards the weakest part, namely, the concave head.

In discussing these failures of concave heads we have the empirical rule of allowing six-tenths the pressure allowed on convex heads, but one can readily see that the stresses set up are vastly different from those on convex heads, especially when it is considered that a vessel subjected to internal pressure tends to assume a spherical shape, and an inquiry as to the foundation of this rule is in order.

Along this line it seems to the writer that our technical colleges might well take up the matter of convex and concave heads and make a thorough inquiry and give the results to the public. They have facilities for doing research work of this sort that are beyond the practical man in the field. Surely the situation warrants investigation, where the factors of safety vary from 5 to 15, and only in the latter is the efficiency of the (usually) single-riveted joint taken care of, and such joints are only about 50 per cent. as strong as the plate.

D. Hogan.

New York City.

Practical Pump Slippage Test

In a large pumping station the amount of slippage was based upon the difference between the calculated displacement and the meter reading. At one time the station slippage recorded was abnormally high. As the combined output of all the pumps entered the same main, some test was necessary to locate the responsible pump.

To do this the station was operated for a specified time with each pump shut down in turn. The pump that was out of service when the best slippage record was made, was identified for special test. The suction side manhole plates were removed, and water was then bypassed to the discharge chamber and allowed to accumulate a pressure there. Large quantities of water rushed from the suction manholes. This indicated that no mistake had been made and resulted in a decision to revalve the pump.

EDWARD T. BINNS.

Philadelphia, Penn.

Explosion of Hot-Water Tank

Power plants are not the only scenes of disastrous explosions. On Oct. 20, 1914, at about 10:30 p.m. on the premises at 18 McCann St., Ilion, N. Y. a hot-water tank exploded, with the results shown in the reproduction of photograph taken the morning after (Fig. 1).

An investigation showed that a system of installing a pressure-reducing valve between the street main and the dwelling is in vogue in the village, as shown in the sketch,

FIG. 1. CONDITION OF PREMISES AFTER EXPLOSION

Fig. 2. The reason for this is that the pressure in the mains is upward of 150 lb. per square inch at many points. Houses on the slopes or tops of hills do not have extraordinary pressure, but the majority of dwellings and business places have this system with a reducing valve, as shown in Fig. 3.

As such valves are absolutely nonreturn, when one is placed in a dwelling without a safety valve of some kind on the house side, there is no automatic means of relieving the pressure if it goes beyond that for which the reducing valve is adjusted. The only means of release is opening some of the various taps by hand.

The family in this case left home to spend the evening with friends, leaving the gas jet burning under the heating coil attached to the hot-water storage tank. This allowed the pressure at the weakest spot to reach the bursting point. Without the reducing valve in the system the pressure would have relieved itself into the city main. That the stop-cock next to the street was open was proved by the fact that the first man to arrive on the scene after the explosion closed it to prevent further flooding of the premises.

In this case the weakest point was the lapwelded type hot-water tank in common use, which let go along the longtitudinal seam from end to end. The force was great enough to tear the seam apart, turn the sheet out flat and double it over from end to end as usually happens in such cases.

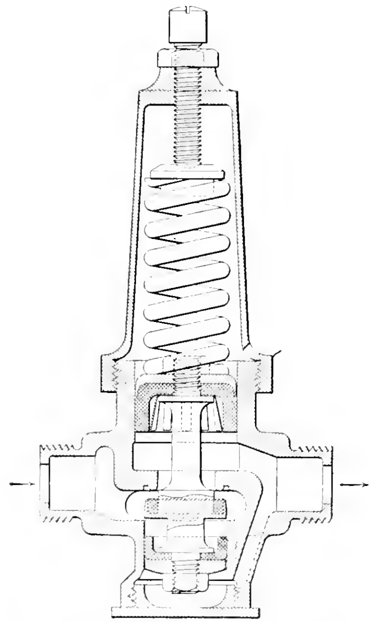


FIG. 3. TYPE OF REDUCING VALVE USED

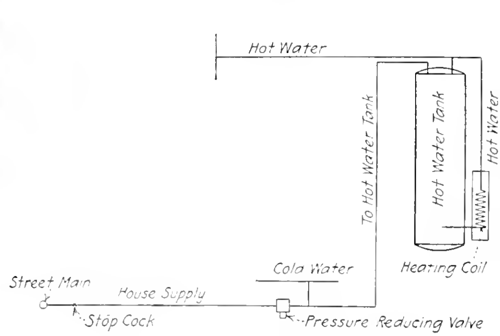


FIG. 2. DIAGRAM OF PIPING SYSTEM

This accident shows that the authorities should insist on the use of safety valves where reducing valves are installed or should not allow the use of the latter at all.

The wrecked dwelling has been rebuilt and the water system installed in this same place without the reducing valve. There are many other places where the old system is in use, and no attempt has been made to correct the fault in such installations. Other municipalities have the same conditions, and other explosions have occurred from the same cause. All should take warning, for the continuation of this system will mean more loss of property and possibly loss of life, which will amount to criminal negligence on the part of those who have the power to correct this condition and fail to do so.

HUBERT E. COLLINS.

Utica, N. Y.

Testing for Open Circuit

In the Feb. 9 issue, page 195, there was described a practical method of testing for an open circuit in a starting resistance. This is to close the line switch, throw the starting-box arm on the first contact, and then bridge between the contact buttons with a piece of metal, such as a screwdriver. Of course, the motor will start if the metal bridges across the open-circuited part of the resistance.

The scheme is possible and no doubt has been used safely by the writer of the article. Nevertheless, it seems dangerous. An open circuit means full line voltage at the break, under the conditions specified. Would one use a screwdriver to close a 550-volt circuit? When the test is made, practically the resistance is in circuit, but should the screwdriver slip and bridge across the contacts at opposite ends of the box, injury to the operator's eyes might result.

R. E. PLIMPTON.

Brooklyn, N. Y.

Oil Separator Failed to Work

An article in the Nov. 3, 1914, issue of POWER, page 650, by T. W. Reynolds, under the above heading, is faulty in the application of the figures arrived at as a solution for the failure of the separator drain to work.

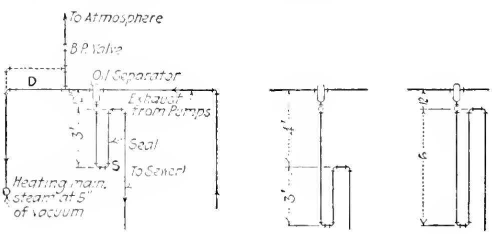


FIG 1 FIG 2 FIG 3

SEAL FOR OIL SEPARATOR

Mr. Reynolds has treated his problem as though the vertical drain pipe from the bottom of the separator dipped directly under the surface of water and oil in a cistern open to the atmosphere. His solutions are correct for this condition, and the dimensions given will work out in practice.

For the arrangement shown in the diagrams, however, the dimensions given are incorrect, for the following reason: With the siphon type of seal (this is the type shown in the sketches) the liquid discharged from the separator must all pass over the crest of the siphon, and the limiting height for proper discharge will be the distance between the crest of the siphon and the allowed height of the liquid in the separator, not, as Mr. Reynolds has erroneously assumed, the sum of the distances from the crest of the siphon to the level of the liquid in the separator and the length of the riser leg of the siphon. This being the case, it is evident that the arrangement shown in Fig. 3 is no better than that shown in Fig. 1 for removing drips from the separator under a vacuum of 5 in.

To fulfill the conditions given in Mr. Reynolds' article the distance between the crest of the siphon and the bottom of the separator would need to be about six feet instead of four feet as shown in Fig. 2. This gives a column of liquid above the crest of the siphon equal to 6 times 0.434 lb. per sq.in., or 2.604 lb. per sq.in., which is slightly in excess of 5 in. of vacuum, which equals 2.46 lb. per sq.in.

With the six-foot dimension instead of the four-foot dimension shown in Fig. 2 of Mr. Reynolds' article, the siphon seal will properly remove all the condensation and drips collected by the separator, and if the riser leg of the siphon were made six feet also (keeping the crest of the siphon six feet from the bottom of the separator, as before outlined) the seal would properly take care of the drips collected by the separator under all conditions of pressure in the heating system from 5 in. vacuum to about $2\frac{1}{2}$ lb. back pressure, that is, pressure above the atmosphere.

E. N. ROBERTSON.

Denver, Colo.

The only thing that is wrong with Mr. Reynolds' proposed remedies is that they are no better than the original, and besides, the figures he uses are for water at 39 deg. F., and not for cylinder oil, although water of condensation will be caught by the separator also.

The original layout has two faults. One is that the top of the seal is too near the same level as the bottom of the separator. Another is that the seal is not deep enough. As the pressure in the main will sometimes be atmospheric, the depth of the seal should be such as to make it safe at atmospheric pressure.

Cylinder oil weighs about 0.39 lb. per square inch per foot of column. I would make the height of the seal rather more than

$$\frac{2.46}{0.39} \times \frac{1}{2} = 3.15\ ft.$$

After being in operation for a few minutes the discharge side of the seal will be full of water and this column of water 3.15 ft. in height will counterbalance about 3.5 ft. of oil. I would therefore place the top of the seal

$$\frac{2.46}{0.39} + (3.5 - 3.15) = 6.65\ ft.$$

below the bottom of the separator.

His sketch No. 3 would not do for any degree of vacuum.

R. MCLAREN.

Medicine Hat, Can.

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*Interesting in this connection are the letters on "Trouble with Oil Separator," Feb. 9, page 207, and Mar. 9, page 344.

Will Quizz, Jr.

SYNOPSIS—Will Quizz, Jr., has a lot of questions to ask Chief Teller about the hydrometer and the various graduations on it.

"Have you tested the brine in the cooling tank lately, Will?"

"Yes, Chief, the specific-gravity age shows 1.206. I took along the other gage, the Baumé, and that showed 26. What do these figures mean?"

"To begin with, get the object of the test clearly in mind. What do you test the brine for, anyway?"

"To find out whether it has enough salt or calcium chloride in it or not."

"Yes, but couldn't you tell that in some other way? Tell me how."

"I could take a graduated flask and draw off a certain amount of the liquid, evaporate the water out of it and weigh the salt it contained, but that would be a lot of bother."

"Suppose, then, you put the same amount of salt into the same quantity of water and weigh the mixture carefully, you would find that for a certain degree of saltness the weight would be the same every time and for a greater or less degree the weight would vary accordingly. This method would not be convenient, either, because care must be taken to get just the correct quantity each time and weigh it carefully. By the way, did you ever think of why they always use those peculiar-shaped bottles or flasks, with long slender necks on which there are graduations, in the laboratories? The idea is to fill to a certain mark in a slender part for accuracy, because a few drops more or less will change the level in a slender tube a lot, while if the mark were on the large body of the flask a difference of considerable magnitude would hardly be noticeable. This same feature applies to the hydrometer, which will be referred to later.

"Now, suppose you used the same flask, but instead of putting the fluid into it, you put certain weights inside of it and put the flask into the brine. It would sink to a certain depth, displacing an amount (measure) of liquid exactly equal to the volume or measure of that part of the flask which was submerged and in weight equal to the total weight of the flask and contents. The level to which it settled could then be marked on its neck so that it might be used again as a test gage for other brine of the same density into which it would settle to the same mark. (This is where the long slender neck of the hydrometer enters in, as referred to before. As the part is slender, it would have to be submerged to a greater extent to displace a small amount of liquid, and the graduations would be farther apart and more easily read.) This method would be more convenient than measuring out a given quantity and weighing it, or evaporating it in the way you just spoke of. Then by a series of tests you might construct a scale on the neck of the flask, so that you would know the density or saltness of the fluid by the depth to which the flask settled and would know by that scale how much salt there was to a cubic foot just as well as if you had gone to the trouble of evaporating the water out. If, after getting your flask nicely graduated for brine, you should put it into pure distilled water it would be likely to sink 'head over heels' unless the neck was very long. This is because the fresh water is less dense and the same vessel would sink deeper or entirely."

"Yes, Chief, I have always understood that objects which will sink in fresh-water streams or lakes will sometimes float in the ocean. So this is the same thing, is it?"

"That's the idea, Will. Then if you were making a hydrometer you would want a fresh-water mark on it as a means of comparison. That's just what Baumé, Twaddell, Beck and others did in constructing an arbitrary scale. The way Baumé first arrived at his scale was, the instrument was submerged in water, by means of the mercury placed in the bottom of the glass, to a certain point which was marked zero. If the instrument was to be used to determine the density or specific gravity of fluids heavier than water, it would be loaded so that it would sink in distilled water almost to the top of the tube, because with the same amount of weight it would not sink so far into the heavier fluid, therefore the graduation was downward from the zero mark made at the surface of the water. The instrument was then put into a solution of 15 parts of salt and 85 parts of water. The point to which it would sink in this solution was marked 15, the distance between these two points was then divided into 15 equal parts, and the graduation was continued beyond 15 in equal divisions. This constitutes the Baumé scale for liquids of greater specific gravity than water. On the other hand, if the instrument was to be used for fluids lighter than water a different scale was used. Baumé used for the zero point the position of the instrument in a solution of 10 parts of salt and 90 parts of water, and for 10 its position in distilled water, and divided this distance into 10 deg., and continued the graduation to the top of the scale.

"There is a tendency now to discard all arbitrary scales in favor of those which read in terms of specific gravity without the necessity of interpolation. The Baumé scale in its time was a very important development, but since the specific gravity of the common fluids has now been established so that the instruments marked with a scale showing the specific gravity by direct reading are preferable. It will be interesting for you to look up a table showing by comparison the Baumé scale and the specific-gravity scale."

"Yes, Chief, such a scale does not mean much, to me at least."

"The specific-gravity scale shows by direct reading the weight of the fluid as compared with the same volume of pure distilled water at 65 deg. That is, the brine in this case is 1.206 times as heavy as water (62.35 per cubic foot), the brine would be $62.35 \times 1.206 = 75.194$ lb. per cubic foot. Any reading of specific gravity multiplied by the weight of water per cubic foot will give the weight per cubic foot of the fluid in question. The reading on the Baumé scale in so called degrees must be transposed by reference to a table to become intelligible."

"The term specific gravity gets me twisted somehow, Chief. See if I have it right. Gravity, or weight, refers to the action of the law of gravitation acting on a given substance. Then the word specific added makes the weight refer to and compare specifically with some other recognized substance, so that the specific gravity of a substance is its weight compared with distilled water, bulk for bulk. Is that right, Chief?"

"Yes. The weight of an object as shown by the scales is independent of its bulk or volume. Its density is its weight per unit of volume (1 cu.ft. for example). Its relative density, or specific gravity, is its weight per unit of volume (as before) specifically compared to the weight of the same volume of a predetermined standard (pure distilled water at maximum density for heavy things is generally used and hydrogen for gases)."

"Another thing puzzles me, Chief. If a body which sinks is put into water it will displace a certain amount of the water which, if allowed to overflow and is measured, will occupy the same space as the body which has been put into the water, but they do not weigh the same. In the other case if the body placed in the water floats, the water which is displaced by it will be of the same weight, while the volume of water displaced will be equal to only that part of the body which was immersed, yet the specific gravity of each is given in the table. How is that determined?"

"The specific gravity of the body heavier or more dense than water is obtained by sustaining some of its weight, or that part of its weight greater than the weight of the water displaced by it, by means of scales with the proper weights on the opposite side; then in every case the weights so required plus the weight of the water displaced will equal the weight of the body being tested, while the ratio of the weight of the body in air and in the water is its specific gravity.

"Density is defined as 'the ratio of mass to volume.' It was considered worth while by the International Congress of Physicists at Paris in 1900 to pass a resolution defining this quality as stated above, because the term is so frequently misused by writers on scientific subjects. Density and specific gravity are by no means the same, although one is proportional to the other. The specific gravity of any substance is defined as the ratio of its density to the density of water.

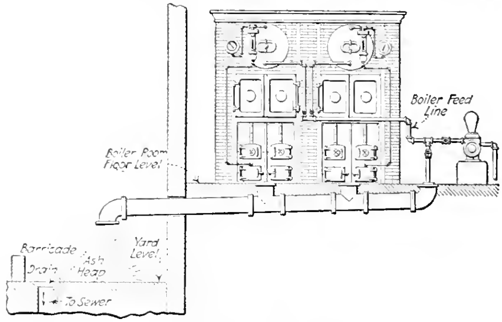
"This old problem may interest you, as it is along the same lines: A canal aqueduct is capable of sustaining ten tons per running foot, the structure filled with water weighs seven tons per foot, and a boat weighing four tons per foot is to pass through the canal. The question is, will the structure sustain the weight when the boat is in the canal?"

Ash Handling by Flushing

An interesting way of handling ashes was observed during a visit among some small plants where the number of boilers did not warrant the use of conveying machinery.

In one plant, a part of which is shown in the sketch, the yard level was below the boiler-room floor. To convey the ashes to this level 6-in. terra cotta soil pipe was laid as shown. The elbow at the extreme right was blanked off and a 2-in. pipe inserted. Water for flushing the ashes out of the pipe is admitted through this line. In this plant water from the feed-pump discharge was used.

The large pipe should be inclined considerably and large clinkers should be broken before entering the tees.



How the Ashes Are Flushed to the Yard

Centrifugal Crude-Oil Pump

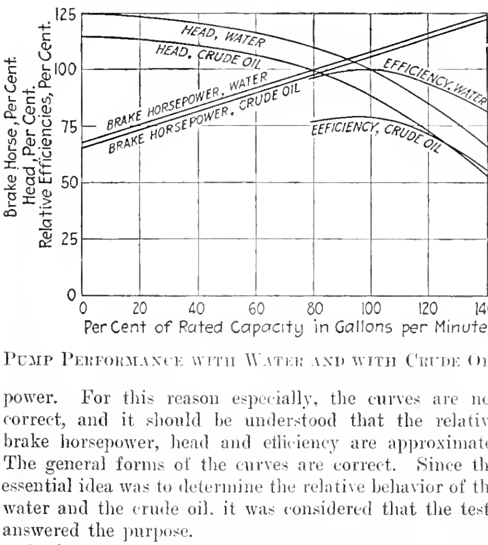
By A. B. Morrison, Jr.

In handling liquids other than water with a centrifugal pump it is necessary to study closely the characteristics of the liquid to be pumped and its behavior under similar operating conditions in order to estimate even approximately what can be expected in the way of power and speeds to produce certain results. A centrifugal pump was used for handling crude oil, replacing a direct-acting steam pump which had been used for the same service. The results obtained were so much at variance with what had been expected that some further tests were made to ascertain wherein the difference lay, and as a result some interesting data were obtained.

The centrifugal pump was designed to deliver 1600 gal. per min. against a head of approximately 60 lb., the head being due almost entirely to the friction in a long line of pipe, the static elevation being slight. The pump was of the single-stage, horizontal split-casing type, direct connected to a steam turbine running at approximately 2000 r.p.m. The guarantees as to head, capacity and steam consumption were made on the basis of pumping clear water. On the basis of such data as were available to the customer, it was assumed that the friction of the crude oil through the discharge pipe would be approximately the same as that of an equal amount of water. It was, therefore, considered that the pump should show the same efficiency, approximately, pumping oil as water. The crude oil had a specific gravity compared to water of 0.865 to 1.

A test was run on the outfit as installed, by measuring the steam to the turbine with a steam-flow meter, the oil by measuring the total amount taken from the tank and dividing by the total minutes run to get the average quantity pumped per minute, and the pressure by means of gages on the suction and discharge, correcting for the difference in level between these gages and the center line of the pump. The speed was recorded at frequent intervals, so that a good record of the pump performance was obtained. Allowing for possible errors in the readings and giving the outfit the benefit of every doubt, the steam consumption, as shown by two different tests, was so much greater than that guaranteed that it was evident something was wrong. A test of the turbine and pump separately, the latter pumping water, showed that both met their respective guarantees as to capacity and efficiency, so there was no apparent reason why the combined outfit should not give the results anticipated if the assumption as to the power required for handling crude oil were correct.

To determine how much difference existed between pumping crude oil and water a series of tests was run on a smaller motor-driven pump, as it was not possible to run the turbine outfit on anything but oil. The pump available for the tests was a small single-stage side-suction one direct-connected to a three-phase motor. It was old and not in good condition. The suction was under a slight pressure and the discharge was into a tank, the pressure on the discharge being varied by manipulating a valve. By means of a float on the tank the average quantity pumped in gallons per minute was determined for five-minute intervals. Gages on the suction and discharge gave the pressures. The gages on the suction were, apparently, not accurate, so that the readings were not wholly reliable. At the time the test was made no wattmeter was available, so it was necessary to read the current and voltage in one phase only and assume an arbitrary constant for efficiency and power factor in calculating the horsepower.



PUMP PERFORMANCE WITH WATER AND WITH CRUDE OIL

For this reason especially, the curves are not correct, and it should be understood that the relative brake horsepower, head and efficiency are approximate. The general forms of the curves are correct. Since the essential idea was to determine the relative behavior of the water and the crude oil, it was considered that the tests answered the purpose.

An inspection of the curves shows the marked increase in the efficiency of the pump when handling water. The brake horsepower was approximately the same in both cases, though the weight of the oil pumped was considerably less and the head generated by the pump less. Through the pump the velocity was very high as compared with that in an ordinary line of pipe, and this high velocity of the oil caused, on account of the viscosity of the latter, the loss in efficiency. This is shown by the head curve. Theoretically, the head in feet should be the same regardless of the liquid pumped, but part of the head generated is lost in the pump because of the greater work required to get the oil through the impeller and casing.

One fact not shown in the curves, but brought out in the operation of the large pump, is that the assumption that the pipe friction is about the same for crude oil and water at the usual pipe velocities is quite correct. The crude oil was pumped through the pipe line in the calculated and desired quantity, and while the required pressure, measured in feet, was slightly greater than that for water, it did not differ from that estimated enough to occasion any trouble. When the velocity is as high, however, as is necessary to get the liquid through a centrifugal pump, the greater viscosity of the oil causes the very marked increase in the friction and power required.

In view of the results obtained with the outfit described, it is a question whether it would not have been better to install a compound direct-acting steam pump. The conditions were not favorable for a steam turbine, as the steam pressure was only 70 lb. gage and the exhaust was to the atmosphere. The pump also ran somewhat slower than the most economical point of the turbine. There is, of course, the argument for greater simplicity in the turbine-driven outfit, both in prime mover and pump, but the ordinary direct-acting steam pump is not likely to give trouble and in the present case the steam consumption would have been no greater and the first cost probably less.

Steam-Turbine Drive for Steel Mills*

The Carpenter Steel Co., of Reading, Penn., furnishes an interesting example of how increased power can be obtained, while reducing the fuel bill and the number of boilers in service. This plant is, moreover, notable as being the first in America, and the second in the world, to apply the steam turbine to the driving of rolling mills through the medium of mechanical speed-reducing gears.

The company does a general merchant trade, consisting of high-grade tool steels, projectiles and special steels for such uses as safety-razor blades, springs, and the like. The two-stand, 18-in., three-high roughing mill now driven by turbine was formerly driven by a 36x36-in. simple slide-valve engine, operated condensing, while the 10-in. and 8-in. finishing mills were driven by belt from a cross-compound, 22&40x48-in. engine, exhausting into a jet condenser, which gave a vacuum varying from 18 to 24 in.

Besides the main power units for the mill, there were in the immediate vicinity several service and boiler-feed pumps and air compressors, the exhaust of which was partially utilized in an open feed-water heater, the surplus escaping to the atmosphere. While no data were obtained regarding the steam consumption when using this equipment, it was necessary that five boilers of a nominal total rating of 1000 hp. be operated continuously.

With a view to reducing power costs, several alternatives were considered. The simple engine driving the roughing mill could have been replaced by a modern compound engine and a modern high-vacuum central condensing plant for the two engines put in. But because of the fluctuations of load on the engines and the small average horsepower required, also because of the first cost of the equipment and the moderate economy, this scheme was not adopted.

The second alternative was the installation of a low-pressure turbo-generator operating on the exhaust of the compound engine to supply current to a motor driving the roughing mill. This did not appear attractive, as it involved a large investment in turbine, generator, switchboard, transmission lines, motor, starters etc., and nearly all the current produced would have been consumed by the roughing mill.

The third plan considered, and the one ultimately adopted, was the installation of a low-pressure turbine to drive the roughing mill. This proposal involved the use of speed-reducing gears, a new expedient for this work, but one which had already been satisfactorily used by James Dunlap & Co., Calderbank Steel Works, near Glasgow, Scotland, where a mixed-pressure turbine, developing 750 hp., drives a three-high, 28-in. plate mill. The speed reduction of the Calderbank mill is made in two steps—first from 2000 to 375 r.p.m. and then to 70, by means of double-helical gears of the rigid-frame type.

As compared to the 15 to 20 per cent. loss of energy in

*From a booklet issued by the De Laval Steam Turbine Co.

the electrical method of driving, the gear loss is not more than 1½ to 2 per cent., besides which it costs less, occupies much less space, is simpler and requires less attention.

For the operation of the roughing rolls at the Carpenter steel plant, an average of about 350 hp. was required, at a speed varying from 60 to 100 r.p.m., while for the greatest efficiency and simplicity of construction a turbine of this capacity should run at about 5000 r.p.m. To secure the reduction of 50 to 1, a two-step reduction gear was adopted, the gear and turbine being mounted on one base plate and the complete unit so located that the shaft of the slow-speed gear is in line with the shaft of the engine which the turbine replaces. The 26-ft. engine flywheel, weighing 47,600 lb. and the engine shaft and bearings were left in place. In order to avoid interruption of work while making the change and also to provide against any possible interruption of service thereafter, the engine was left intact and only the connecting-rod removed, a distance piece, which serves also as one of the flanges of the flexible coupling on the low-speed gear shaft, being bolted onto the crank disk. After the turbine was installed it was thus possible to operate it without load in order to try out the installation, during which period the engine continued to drive the mill and practically no time was lost in changing from engine to turbine drive.

The turbine, which is of the mixed-flow type, was built by the De Laval Steam Turbine Co., and contains eight pressure stages, the first pressure stage consisting of two velocity stages. The low-pressure steam, that is, the exhaust steam from the engine, is admitted at the third pressure stage and expands through the remaining stages to exhaust pressure.

The turbine is designed to operate under four different steam conditions: When receiving engine exhaust at a pressure of 3-lb. gage, and when exhausting into a vacuum of 27 in., it is to develop 350 hp. at speeds corresponding to 70 to 100 r.p.m. of the mill shaft, under which condition it is guaranteed to take not more than 26 lb. of steam per brake horsepower per hour, as measured at the end of the second gear reduction. It is also to be able to carry the normal load of 350 hp. when using steam at 120 lb. pressure gage and exhausting to a 27-in. vacuum, under which conditions it is guaranteed to take not more than 17½ lb. of steam per brake horsepower per hour. When receiving both high- and low-pressure steam and exhausting to vacuum, the turbine is to be able to carry 600 b.hp. continuously. It is also to be able to carry a load of 600 hp. on high-pressure steam only, as when the compound engine is not running. Under these conditions it is guaranteed to take not more than 15.7 lb. of steam per brake horsepower per hour.

The turbine is also to be able to carry normal load noncondensing when receiving steam at 120 lb. and exhausting to atmosphere, making it possible to inspect or repair the condenser or circulating pump without interfering with the operation of the mill.

The roughing mill is three-high and consists of two stands of 18-in. rolls. It is manually operated, two men being employed on each stand. The reduction of a 4x4-in. billet, 17.6 in. long, weighing 80 lb., to an oval 1¾ in. wide is performed in thirteen passes, occupying 41⅗ seconds.

Owing to the fact that the finishing mill cannot take high-carbon steel as fast as the roughing mill can supply it, only one billet is usually in the latter at one time, but when rolling low-carbon steel, two billets are in at once. When handling one billet no speed variation is perceptible on the tachometer, which is permanently attached to the 600-r.p.m. shaft, while when handling two billets the speed drops about 2 per cent. The fact that there is no drop of speed with one billet in the mill shows that the heavy flywheel is not required for power storage under such conditions. By setting the governor for a greater drop in speed before the high-pressure valve opens, the power-storage capacity of the flywheel can be utilized and unnecessary use of high-pressure steam avoided.

The compound engine, operating noncondensing, ordinarily supplies steam to the turbine under 3 to 3½ lb. back pressure, the pressure being regulated by a multiport safety exhaust outlet valve. The roughing mill, however, is not required at certain times, the steel being taken directly to the finishing mill, at which times the valves between the engine exhaust and the turbine, and between the turbine exhaust and the condenser can be closed and the valve between the engine exhaust and the condenser opened, permitting the engine to operate condensing.

In the low-pressure supply line to the turbine is placed a receiver steam separator. To insure dry steam, a coil of 1-in. copper pipe, inserted in the 12 ft. of 10-in. pipe between the separator and the turbine, is kept filled with live steam and drained by a steam trap. Adjacent to the low-pressure throttle valve of the turbine is a multiport flow valve, designed to prevent the vacuum from backing up from the condenser through the turbine into the engine exhaust line. Without this valve there is always a possibility of air being drawn in through leaks in the exhaust line and through piston-rod and valve-stem packings of the engine at times when there is little or no exhaust steam available. Such air would interfere with the operation of the condenser.

The condenser, which is of the multijet type, is located just outside of the engine room and is protected by a 10-in. multiport atmospheric relief valve. With a water temperature of 72 deg. F., the condenser maintains a vacuum of 28.2 in. with the barometer at 29.78 in. As there was a surplus of exhaust steam for operating the circulating pumps, and also because of the desirability of a simple, reliable condenser, this type was considered best.

The circulating water for the condenser is supplied by a centrifugal pump driven by a mixed-flow geared turbine of the velocity-stage type with two sets of nozzles and designed to operate either with steam at 120-lb. gage or with steam at 3-lb. gage, exhausting to a 27-in. vacuum. It exhausts through a 10-in. pipe to the same condenser that serves the main unit. The speed-reducing gears permit both turbine and pump to run at the best speeds for economy, viz., 5000 r.p.m. for the former and 1500 r.p.m. for the latter. The turbine can be started noncondensing and will carry full load with high-pressure steam alone, thus providing both for starting the pump before the condenser is in operation and for carrying its full load without taking low-pressure steam. Surplus exhaust steam not used by either turbine passes to the open-feed water heater, which also receive the exhaust from pumps, air compressors, etc.

The cost of the installation, consisting of the turbine, reduction gear, condenser, piping, circulating pump, valves, etc., erected complete, was not far from $25,000, and owing to the better economy secured through its use, it has been possible to reduce the boilers in operation from 1000 hp. to about 600 hp. This indicates a saving approaching $15,000 per year.

Cause of the "San Diego" Explosion

The cause of the low water which allowed the boiler aboard the U. S. armored cruiser "San Diego" to become overheated and explode on Jan. 21, it is learned, was the top of a bucket strainer in the feed tank came off, dropping to the bottom of the strainer, partly closing the opening of the suction pipe to the feed pumps. One-half of the supply of feed water was thus shut off and as water was being carried rather low and the engines running at full power, it was impossible to get sufficient water to all the boilers, with the result that five boilers were badly overheated, when the explosion occurred.

The "San Diego" (originally the "California," built in 1907) is the flagship of the Pacific fleet that had just completed a four-hour speed trial. Her triple-expansion engines indicate 30,000 hp., and are capable of developing a speed of 22.5 knots. The boilers are of the B. & W. marine type (forced draft), with 1592 sq.ft. of grate surface, and 70,000 sq.ft. of heating surface. She carried a crew of 822 men, nine of whom were killed as a result of the explosion.—A. P. Connor, Washington, D. C.

Foreign Trade Opportunities

Brass and phosphor bronze wire	No. 15,678
Centrifugal pumps	No. 15,714
Concrete mixers	No. 15,744
Electric motor	No. 15,699
General agency	No. 15,691
General agency	No. 15,740
Iron and steel	No. 15,757
Machinery and tools	No. 15,743
Machinery	No. 15,727
River dredge and pumping plant	No. 15,675
Steel forgings, castings, etc.	No. 15,673
Sugar machinery	No. 15,701
Tools and technical appliances	No. 15,692
Vacuum cleaners	No. 15,718
Vacuum cleaners	No. 15,750
Wire, iron and steel bars, paint colors, etc.	No. 15,677
Wire machinery	No. 15,690
Wrought-iron fittings	No. 15,676

Addresses and detailed information may be obtained from the Bureau of Manufactures, Washington, D. C., and its branch offices, as follows: New York, Room 409, U. S. Customhouse; Boston, 752 Oliver Bldg.; Chicago, 629 Federal Bldg.; St. Louis, 402 Third National Bank Bldg.; Atlanta, 521 Post Office Bldg.; New Orleans, 1020 Hibernia Bank Bldg.; San Francisco, 310 U. S. Customhouse; Seattle, 922 Alaska Bldg.

Recent Court Decisions

Digested by A. L. H. STREET

Fires Set By Traction Engines—One operating a steam roller or traction engine along a street or highway must use that degree of care to avoid setting fire to adjoining property which an ordinarily careful person would use under the same circumstances. And if a law or ordinance requires such engines to be equipped with spark arresters, the owner is liable for loss directly attributable to failure to comply with the requirement. These rules were lately announced by the Delaware Superior Court in the case of Cecil vs. Mundy, 92 "Atlantic Reporter" 850.

Classification of Fuel-Gas Rates—A public-service corporation engaged in furnishing gas for heating, lighting and power purposes may lawfully classify its rates according to the nature of the service afforded, as well as the quantity of gas furnished, if the classification is not unfair or discriminatory against other classes of consumers. The West Virginia Supreme Court of Appeals has just handed down this decision in the case of Elk Hotel Co. vs. United Fuel Gas Co., 80 "Southeastern Reporter," 922. But the court holds that the same rate and service must be offered alike to all consumers similarly situated and provided with the same character of equipment.

Impairment of Franchise Rights—After a power company has acquired a right to use streets and highways for the maintenance of transmission lines under existing constitutional and statutory provisions, the right cannot be impaired by a subsequent constitutional amendment. Hence, the provision incorporated into the Michigan constitution in 1909, to the effect that public-service corporations shall not be permitted to use the streets of a city without obtaining a franchise from the city, cannot be deemed to impair a previously acquired right to maintain a line along certain streets. (Michigan Supreme Court, City of Lansing vs. Michigan Power Co., 150 "Northwestern Reporter," 250).

Washroom Law Sustained—In 1913 the Illinois Legislature enacted a law which, in effect, requires that owners and operators of coal mines, steel mills, foundries, machine shops, etc., provide adequate washroom facilities to enable employees whose work in such employments causes their persons or clothing to be covered with grime, dirt or perspiration to such an extent as to render their remaining in that condition unhealthful or offensive to persons with whom they come in contact in leaving their work, to change their clothing and wash before leaving. In the case of People vs. Solomon, which was recently before the Illinois Supreme Court, the validity of this regulation is upheld. (106 "Northeastern Reporter," 458.) Doubtless it will be construed as extending to the employment of stationary engineers and firemen in the employments covered by the law. In fact, the decision seems to hold that it covers all employments where "employees become covered with grease, smoke, dust, grime and perspiration" to the extent that their remaining in that condition would be unhealthful or offensive to the public.

The Engineer as an Expert Witness—The qualifications of an engineer to testify as to the availability of means to prevent injury to adjoining property in the cleaning of locomotive boilers were under consideration recently before the Pennsylvania Supreme Court in the case of Vile vs. Pennsylvania R.R. Co. (91 "Atlantic Reporter," 1049). In this case the plaintiff, an occupant of land adjacent to the defendant's premises, recovered judgment for injury to the land through the fact that smoke, soot, ashes, etc., were cast upon it in the defendant's process of cleaning its locomotive boilers by means of compressed air. A consulting engineer, who testified in the plaintiff's behalf, admitted that he had had no experience with locomotive boilers, but that they presented no problems with respect to such processes that do not equally apply to other boilers, and that he had made a special study of power and combustion, and had had experience in doing away with the evils of smoke, etc. The Supreme Court holds that he sufficiently qualified himself as an expert to enable him to testify that in such cases as this one, deposits of soot on premises near those upon which boilers are cleaned can be avoided by using brushes instead of blowers and by washing the smoke to remove injurious impurities. The court finds that this method has been found to have been effectively used by railroads and in stationary plants for 70 years, and that the compressed-air method was adopted merely to save time and expense. And it is further found that the damage which the plaintiff sustained could have been avoided by the defendant's discharging the noxious fumes through a high chimney, and that it is no defense to such a suit that the compressed-air method is in common use.

PERSONALS

Edward Wegmann and A. G. Hillberg have taken offices in the South Ferry Building, New York City, to engage as consulting hydraulic engineers on water-works, water-power developments, sewer systems, irrigation and drainage projects. Mr. Wegmann was for more than 30 years connected with the construction of the Croton Water-Works. He was the last chief engineer of the Aqueduct Commissioners and subsequently for four years consulting engineer of the Department of Water Supply, Gas and Electricity. He is well known through his books—"Design and Construction of Dams" and "The Water Supply of the City of New York." Mr. Hillberg has been connected with large hydro-electric developments, notably the Mississippi River Power Co.'s plant at Keokuk, Iowa. For the past two years he has been associate editor of "Engineering Record," in charge of hydraulics.

ENGINEERING AFFAIRS

The Illinois Section of the American Water Works Association, succeeding the Illinois Water Supply Association, held its seventh annual meeting at the University of Illinois, Champaign-Urbana, Ill., Mar. 9 to 11. The program included the following papers: "The Design and Operation of Intermittently Operated Water Purification Plants," E. B. Black, consulting engineer, Kansas City, Mo.; "Wash Water Salvage at Champaign and Urbana," H. E. Babbitt, instructor in University of Illinois; "Relation Between Bacteriological Standards and Vital Statistics at Hannibal, Mo.," W. F. Monfort, consulting chemist, St. Louis, Mo.; "Loss of Head on Strainers of Water Filters," Langdon Pearse, division engineer, sanitary district of Chicago; "Experiences in Rebuilding and Reinforcing a Water Works System," O. T. Smith, superintendent and manager, Water Works Co., Freeport, Ill.; "The New Harrisburg (Ill.) Filter Plant," L. F. Payne and Glen W. Bass, Central Illinois Public Service Co.; "Soft Water" (Illustrated), Cass L. Kennicott, vice-president and general manager, The Kennicott Co., Chicago; "Water Works Improvements at Springfield, Ill." (Illustrated), W. J. Spaulding, commissioner of public property, Springfield, Ill.; "Coal Mining Operations" (Moving Pictures), R. Y. Williams, director Miners' and Mechanics' Institute, University of Illinois; "Coal Resources of the Danville Area," F. H. Kay, assistant state geologist, Illinois; "Investigation of Artesian Water Supplies in the Chicago Area" (Illustrated), Frank De Wolf, director Illinois State Geological Survey; "The New Filtration Plant at Decatur, Ill." (Illustrated), Harry Ruthrauff, commissioner of public property, Decatur, Ill.; "The New Filtration Plant at Quincy, Ill. (Illustrated), W. R. Gelston, superintendent Citizens Water Works Co., Quincy, Ill.; "Kinks in the Control of Hypochlorite at Denver," W. W. DeBerard, western editor, "Engineering Record," Chicago; "River Sand as a Filter Medium," L. A. Fritze, city chemist, Moline, Ill.; "Choice of Alloys in Connection with Water Works Equipment," Horace Carpenter, engineer, Sanitary District of Chicago; "The Practical Value of Publicity to the Water Works Man," S. C. Hadden, associate editor, "Engineering and Contracting," Chicago; "Treatment of Water for Locomotive Use," W. A. Pownall, water engineer, Wabash Railway, Decatur, Ill.; "The Possibilities of Improved Water from Deep Wells in Northern Illinois," C. B Williams, hydraulic and sanitary engineer, Chicago; "Water Supply of Longview, Texas," Paul E. Green, civil and sanitary engineer, Chicago; "Arsenic in Filter Alum," Edward Barton and A. N. Bennett, state water survey, University of Illinois; "Some Features of the Ontario Statutes and their Administration Affecting Water Supply and Sewerage," F. A. Dallyn, provincial sanitary engineer, Toronto, Canada; "The State Public Utilities Commission of Illinois and Water Works," W. A. Shaw, member Public Utilities Commission, Springfield, Ill.; "State Regulation of Municipally Owned Plants," C. M. Larson, chief engineer, Railroad Commission of Wisconsin; "The Illinois Utilities Commission and the Water Works Companies," C. G. Bennett, mechanical engineer, Illinois Utilities Commission, Springfield; "The Application of the Theories of Regulation to the Management of Utilities," Douglas A. Graham, principal assistant engineer, Dabney H Maury, Chicago; "Economic Waste Aspects of Water Works

Operation," Ralph E. Heilman, assistant professor of Economics, University of Illinois; "Ancient and Modern Accounting for Utilities," Edward A. Pratt, president Edward A. Pratt Audit Co., Peoria, Ill.; "Water Waste Prevention by Individual Meter vs. District Meters," R. O. Wynne-Roberts, consulting engineer, Regina, Sask., Canada. The exhibits of the Associates were shown in Engineering Hall.

NEW PUBLICATIONS

COX'S COMMERCIAL CALCULATOR. By Edward L. Cox. Published by Funk & Wagnalls Co., New York. 7x11 in.; 203 pages; cloth. Price, $10.

A collection of tables, from which the product of any two numbers whose sum does not exceed 202,000 can be found. The use of the tables is briefly explained and illustrated. Two key numbers must be obtained from the numbers to be multiplied, by the use of a simple formula. Each key number forms an unusual index to the table numbers required, in that the digits must be taken in order from right to left to find the correct page, column, section and line. The product desired is the difference of these two table numbers. The tables themselves are conveniently arranged and the book is valuable for commercial and scientific purposes in which products up to ten billion, accurate to the smallest unit, are essential.

GEARING. By A. E. Ingham. Published by D. Van Nostrand Co., New York. 5½x8½ in.; 181 pages; cloth. Price, $2.50

To the outsider the acquiring of practical gearing knowledge has been somewhat of a task. In one book he may find a complicated discussion of gearing principles; another may give him the manufacturing methods, while he must consult a third to find practical methods of design. Mr. Ingham has endeavored in the one book to cover the whole broad field of gearing. Nearly half of the 181 pages relate to spur gears, but in this section is stated the theory of the involute and cycloidal curves, which is later applied to the bevel, worm, spiral and helical gears.

The reader is given methods of drawing gear-teeth curves, such as the Brown & Sharpe single curve and the Grant odontograph; is shown how to calculate speed ratios for simple and compound gearing; and is informed regarding the materials and proportions of gears for the efficient transmission of power. The diametral, circular and metric systems of gear pitches are described. Numerous working drawings, cross-sections as a rule, accompany the design directions, while the manufacture and application of the various gears are illustrated by photographs. Formulas are given so that the reader may understand and pass through all the steps necessary to obtain the complete dimensions, but the numerous curves and tables, demonstrated by numerical examples, afford many short cuts. In general, Mr. Ingham's work offers a simple and adequate presentation of the information required in the design and application of gearing.

BOOKS RECEIVED

OXY-ACETYLENE WELDING AND CUTTING. By Calvin F. Swingle. Frederick J. Drake & Co., Chicago, Ill. Cloth; 190 pages, 4¼x6¾ in.; 76 illustrations. Price, $1.

HANDBOOK OF MACHINE SHOP MANAGEMENT. By John H. Van Deventer. McGraw-Hill Book Co., Inc., New York. Leather; 374 pages, 4x7 in.; 244 illustrations. Price, $2.50.

ELEMENTARY ELECTRICITY AND MAGNETISM. By W. S. Franklin and Barry MacNutt. The Macmillan Co., New York. Cloth; 174 pages, 4¾x7¾ in.; 152 illustrations. Price, $1.25.

ADVANCED THEORY OF ELECTRICITY AND MAGNETISM. By W. S. Franklin and Barry MacNutt. The Macmillan Co., New York. Cloth; 300 pages, 5¾x8¾ in.; 217 illustrations. Price, $2.

SANITARY REFRIGERATION AND ICE MAKING. By J. J. Cosgrove. Technical Book Publishing Co., Philadelphia, Penn. Cloth; 331 pages, 5½x8½ in.; 103 illustrations; tables. Price, $3.50

PREVENTING LOSSES IN FACTORY POWER PLANTS. By David Moffat Myers. The Engineering Magazine, New York. Cloth; 560 pages, 5x7½ in.; 68 illustrations, including several plates. Price, $3.

Antimold and Antibug Varnish for Books—The following ingredients make a varnish that has been found very useful in protecting books from mold and from roaches: Bichloride of mercury, 2 parts; orange shellac, 20 parts; oil of turpentine, 250 parts, and the balance up to 1000 parts, 95 per cent. ethyl alcohol.—"The Canal Record," Dec. 16, 1914.

TRADE CATALOGS

Elliott Co., 6910 Susquehanna St., Pittsburgh, Penn. Bulletin G. Steam traps. Illustrated, 12 pp., 6½x10 in.

The Tracy Engineering Co., San Francisco, Calif. Catalog No. 10. Steam purifier. Illustrated, 20 pp., 6x9 in.

The Blaisdell Machinery Co., Bradford, Penn. Loose Leaf Catalog. Air compressors, vacuum cleaners. Illustrated, 6x9 in.

Semet-Solvay Co., Syracuse, N. Y. Pamphlet. Solvay 75% Calcium Chloride for refrigeration. Illustrated, 16 pp., 4x9 in.

B. F. Sturtevant Co., Hyde Park, Mass. Bulletin No. 206. Generating sets with vertical engines. Illustrated, 20 pp., 6½x9 in.

Lunkenheimer Co., Cincinnati, Ohio. Booklet. "Ferrenewo" valves. Illustrated, 10 pp., 3½x6 in. Booklet. "Clip" valves. Illustrated, 10 pp., 3½x6 in.

The Bristol Co., Waterbury, Conn. Bulletin No. 192. Bristol's long-distance electric transmitting and recording system. Illustrated, 8 pp., 8x10½ in.

Chicago Pneumatic Tool Co., Chicago, Ill. Bulletin No. E-35. Universal electric drills. Illustrated, 8 pp., 6x9 in. Form No. 212. Boyer riveting hammer. Illustrated.

Harrison Safety Boiler Works, Philadelphia, Penn. Cochrane Engineering Leaflet No. 17. "Reducing Boiler-Room Costs by Heating and Softening the Feed Water." Illustrated, 20 pp., 6x9 in.

Buffalo Forge Co., Buffalo, N. Y. Catalog No. 200. Planoidal Fans. Illustrated, 48 pp., 6x9 in. Catalog No. 201. Niagara conoidal fans. Illustrated, 64 pp., 6x9 in. Bulletin No. 182-E. Electric fans for blowing, ventilating, cooling, drying. Illustrated, 32 pp., 6x9 in.

Charles T. Main, engineer, Boston, Mass., is distributing a handsomely printed volume of halftone illustrations of industrial plants of his design. This follows a similar work issued some time since, and is inscribed "Industrial Plants, Vol. 2." Prospective builders of anything from cotton mills to central stations will find in it worth-while suggestions.

BUSINESS ITEMS

The New River Co., equipment sales department, Macdonald, West Virginia, is sending out a list of second-hand power plant equipment, quoting prices and terms.

Harry J. Ernst, advertising manager of the D. T. Williams Valve Co., Cincinnati, Ohio, has been elected treasurer of the company, succeeding R. E. Mullane, recently elected president.

The Link Belt Co., Chicago, Ill., is sending out bulletins descriptive of the Wendell centrifugal coal drier, and the Link-Belt electric hoist. Both bulletins show illustrations of the equipment and go into details of construction. Copies are sent on request.

The Chicago office of the Terry Steam Turbine Co., Hartford, Conn., is now in charge of A. W. de Revere, located in the Peoples Gas Building. This company has also opened an office in the Michigan Trust Bldg., Grand Rapids, Mich., in charge of A. L. Searles.

The Sprague Electric Works of General Electric Co. has recently opened a branch sales office in Cleveland, Ohio. It will be in charge of Frank H. Hill, manager, who also has charge of the Pittsburgh office. The Cleveland office will be located in the Illuminating Building.

The sales of Sarco steam traps, Sarco vacuum valves, and Sarco temperature regulators have shown such substantial continued increases during the past half year, that the Sarco Engineering Co. of New York has moved its offices into larger quarters in the new South Ferry Building, 1 State St.

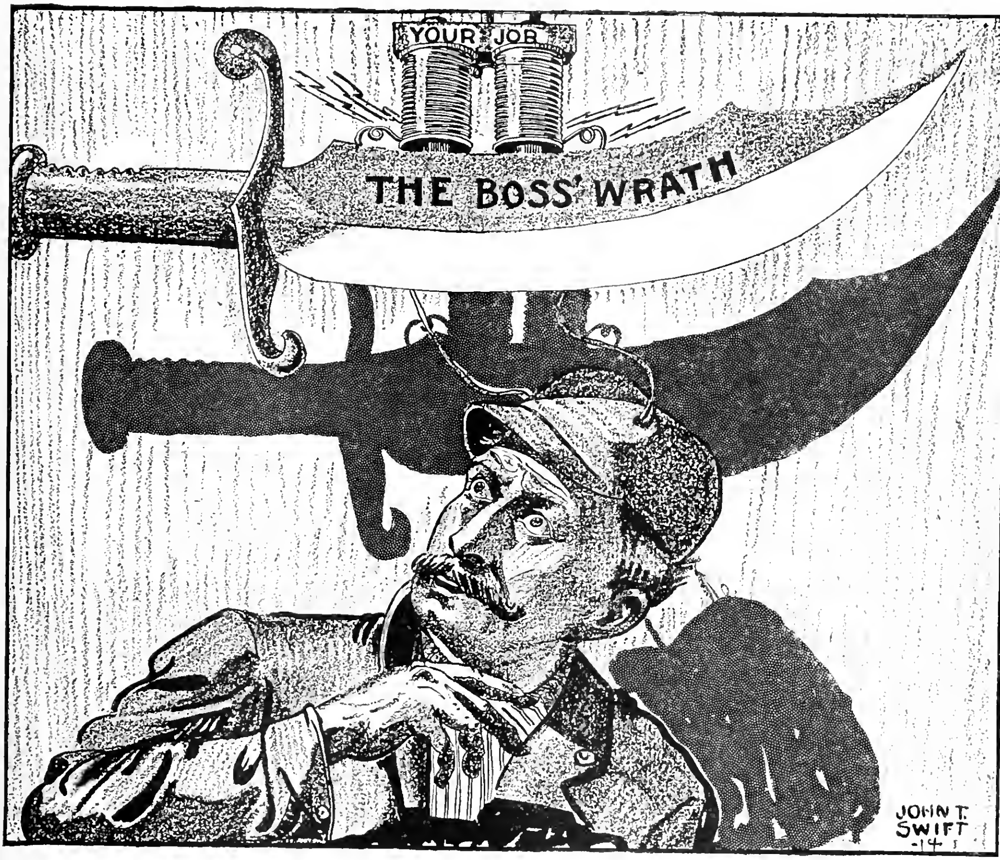
A very interesting booklet has just been published by the Murray Specialty Mfg. Co., 55 West Woodbridge St., Detroit, on "Boiler Feed—How To Regulate It." It's a 32 page booklet describing the apparatus in detail and containing many clear and instructive illustrations. Testimonial letters and installation details are also given. A request brings a copy.

The Harvard Medical School has recently given an order to the Builders Iron Foundry, Providence, R. I., for two extra heavy meter tubes for boiler feed service. This institution already has two Venturi meters on its heater conservation system and six Venturi meters for brine measurement. M. L. Bayard & Co., of Philadelphia, have recently placed an order for 36 double dial indicating instruments to be used in connection with effluent controllers at the Cleveland filtration plant.

The Southwark Foundry & Machine Co., Philadelphia, Penn., has secured the exclusive United States license to manufacture the Harris valveless engine, Diesel principle, which will hereafter be known as the Southwark-Harris valveless engine. The engine will be built in sizes from 75 b.hp. to 1000 b.hp. Leonard B. Harris, the inventor of the Harris valveless engine will be with the company as consulting engineer and naval architect, and J. P. Johnston will be in charge of oil engine sales.

POWER

Vol. 41 NEW YORK, APRIL 6, 1915 No. 14



The Sword of Damocles

CREEPY, EH? No need to be if you KNOW your work. Merely a matter of carrying mental voltage enough to hold that meat-ax in place. Even tho' your job is a horseshoe magnet, yet—LUCK won't do. Soon another nick will appear on that handle, recording your demise if you have nothing on your mind but your hair. GET BUSY. Put some "JUICE" under your hat. And begin today. NOW!

Heating and Ventilating System of American Cigar Co.'s Plant

By W. L. Durand

SYNOPSIS—Modern demands for comfort and convenience in the heating and ventilation of factory buildings have far outrun the relatively simple requirements of former years. An interesting example of modern tendencies is found in the equipment of a new factory erected for the American Cigar Co.

The new building of the American Cigar Co., Garfield, N. J., covers an area of 15,000 sq.ft.; it is five stories high and has a floor area of 50,000 sq.ft. It is used exclusively for the manufacture of cigars and about 1000 persons are employed.

The power plant, Fig. 1, is located in the basement, with natural light for the engine room and a convenient arrangement for handling the coal and ashes.

The boiler room is equipped with two 75-hp. horizontal return-tubular boilers arranged in a battery. While 125 lb. pressure is carried, the boilers are built to withstand 150 lb. The boiler furnaces are equipped with bridge-wall dampers and ducts leading to the rear of the setting, so that if it is desired later to increase the output by the addition of forced draft, no changes to the setting will be necessary.

The water for the boilers is taken from a driven well in the pump room. Two 4½x2¾x4-in. duplex, outside-packed plunger pumps are so connected that either one can be used to pump water from the well to the feed-water heater, to the boilers direct, or from the feed-water heater to the boilers. The steam piping is arranged to control the pumps by throttle valves when pumping from the feed-water heater to the boilers, or by means of a float in the feed-water heater when pumping from the well to the heater. This arrangement permits of one pump being used to handle makeup water to the feed-water heater under automatic control, the other to be used as a boiler-feed pump; in case of a breakdown to either pump, water can be fed direct to the boilers by the other.

A hydraulic damper regulator is used in connection with a balanced damper in the main smoke flue. If forced draft is installed this will also be used to operate a balanced valve in the steam connection to the forced-draft fan, permitting automatic control.

Bituminous coal is burned in the boilers. It is stored in a pocket adjacent to the boiler room, the coal being supplied from a driveway overhead. The ashes are removed by an overhead trolley which discharges directly to the driveway.

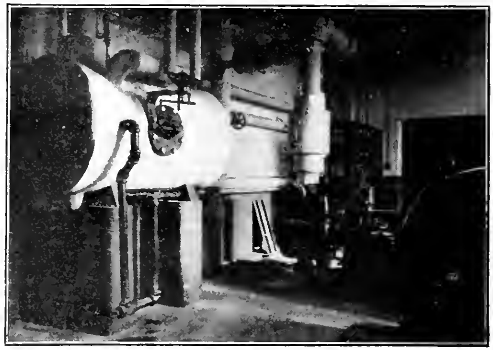


Fig. 1. Partial View of the Engine Room

The engine room is equipped with a 10x12-in. high-speed engine directly connected to a three-wire, direct-current 110-volt generator. It was the first intention to use a four-valve engine, but after going into the situation it was found that engine economy was of value only during the summer months when the load was the lightest, and that the saving would not be sufficient to warrant the increased cost of both engine and generator. The increased cost of the generator would be almost as much as that of the engine, due to the lower speed of this type of engine. No breakdown service or extra unit was installed,

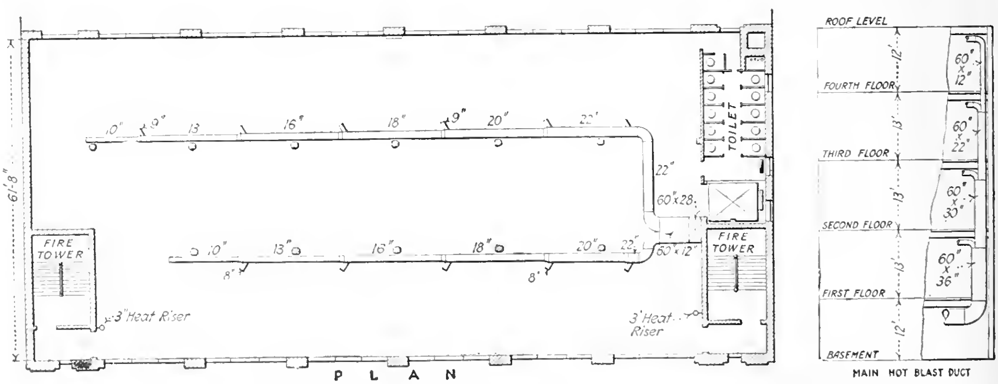


Fig. 2. Plan and Elevation of the Hot-Air Ducts

since the character of this factory did not seem to warrant the extra expenditure.

Exhaust steam from the engine and pumps passes to a feed-water heater and is then used for heating hot-blast coils, with provision for using live steam from the boilers through a double set of reducing valves.

The building is heated by means of a hot-blast system supplemented by a few coils and radiators. The air in entering passes first through a tempering coil, an air washer, and a reheater to the intake of the supply fan. From the supply fan it is distributed by a main riser with two branch ducts on each floor. Fig. 2 is a plan and elevation of the hot-air ducts. Fig. 3 is a plan view of the engine, boiler and air-washing rooms.

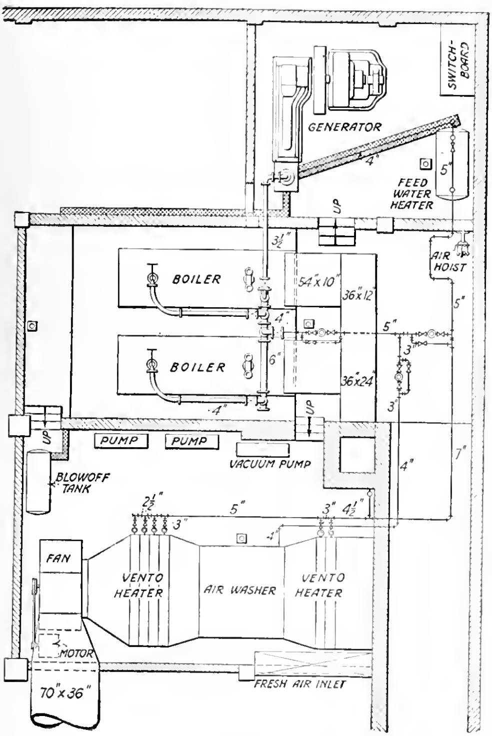


FIG. 3. PLAN OF ENGINE, BOILER AND AIR-WASHING ROOMS

The tempering coil consists of two groups of 60-in. cast-iron heaters set on 5-in. centers. Each group contains 20 sections, making a total of 640 sq.ft. The coils raise the air to a certain necessary minimum temperature, as later described, before passing to the air washer.

The air washer consists of a metal spray chamber through which the air is drawn. Under the chamber is a tank which is kept filled with water. A centrifugal pump driven by a directly connected motor draws water from this tank and forces it through the spray nozzles. The nozzles, of which there are approximately seventy, are uniformly distributed over the cross-section of the washer, so that this chamber is filled with a fine mist so dense that it is impossible for the air to carry any dirt through it without the latter becoming wet and heavy. At the end through which the air leaves the spray chamber is placed a set of eliminator plates, which extract all the water and dirt. These plates are kept flooded, so that dirt is washed into the settling tank.

This apparatus is provided with an arrangement for automatically controlling the humidity. The spray water is heated when the humidity is too low, in order to increase the evaporation; this heating is controlled by a

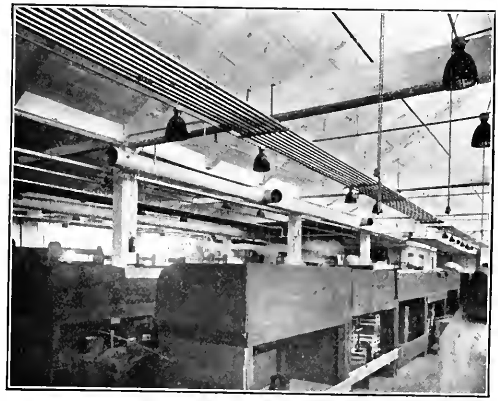


FIG. 4. SHOWING AIR DUCTS AND STEAM COILS ON THE TOP FLOOR

thermostat placed in the air duct leading away from the apparatus. While one of the functions of an air washer s to remove dust and floating solid matter from the air before entering the rooms to be heated, the principal reason for installing one in this factory is for humidifying the air, and in order to give the best possible conditions for the manufacture of cigars it was decided to maintain a humidity of at least 65 per cent. at all times.

For the proper operation of this apparatus the temperature of the entering air should fulfill two conditions—it must be not less than 32 deg. F. to avoid danger of freezing the water in the washer, and it should have such a temperature that when saturated, as it is when leaving the washer, it will carry such a moisture content as will give it, at the desired room temperature, a relative humidity of 65 per cent.

The heating stacks consist of four groups of 60-in. cast-iron heaters. Each group contains 22 sections, making a total of 1408 sq.ft.

The fan is a 54-in. diameter multivane, and it has a capacity of 25,000 cu.ft. of air per minute against a pressure of 1 in. of water. It is driven by a directly connected 10-hp. engine. The reason for using an engine in preference to a motor is that in case of a breakdown to the engine generator set the building could still be kept warm and work would not have to be entirely suspended.

The factor determining the amount of air circulated was the number of occupants. This being fixed, the heat losses were computed, and the required temperature of air from the reheater for extreme conditions was found to be 120 deg. F., which temperature is given by the arrangement outlined above.

On the first floor, which has an extended wing, and on the top floor, Fig. 4, steam coils are installed to offset the heat losses through the roof. This is necessary to prevent an excess of air on these floors, which would occur if these losses were taken care of by the hot-blast system. The arrangement of the air ducts and outlets on the other floors is shown in Fig. 5.

The entire heating apparatus is governed by an automatic temperature-controlling system. One thermostat is located between the primary heater and the air washer, controlling supply valves on both sections. The valves are fitted with differential springs, the outer section being the last to close, so as to maintain temperatures from 45 to 55 deg. F., as desired. One thermostat is located in the air washer, as previously described. One thermostat of the two-relay pattern, adjustable from 65 to 125 deg., is located in the duct beyond the reheater and controls the four valves on the steam supply to the reheater. Two thermostats on the first floor, and three on the top floor control the ceiling coils.

Fig. 5. Arrangement of Air Ducts and Outlets on the Center Floors

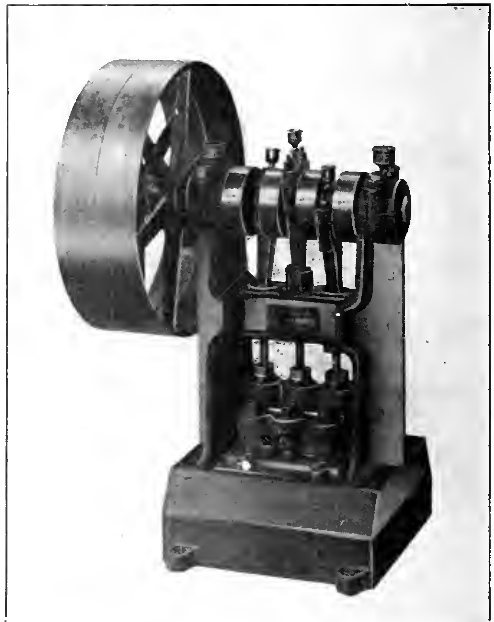
A vacuum system is used in connection with all coils, radiators and stacks. The condensation is carried to a 6x7x8-in. vacuum pump with suction strainer and vacuum governor. The discharge on the pump is carried to a standpipe with a vent to the atmosphere, instead of the customary air-separating tank. From there it flows to the feed-water heater. With a heating system of this character it is possible to carry a vacuum of 1 to 2 in. of mercury on the steam side of the system and 7 to 8 in. on the return side.

The covering is 85 per cent. magnesia for all steam pipes in the basement, being 2 in. thick on the high-pressure and 1 in. on the low-pressure. The exhaust pipe, which is in a chase, is covered to the fourth floor, where the last connection is taken off. No vacuum return pipes are covered.

As this is one of the first buildings in this country used exclusively for the manufacture of cigars to install an air washer and is in the nature of an experiment, the comparison of the results obtained at this factory with similar factories owned by the same company, but heated by steam with no ventilation and humidity control, will be watched with interest.

Single-Acting Hydraulic Pump

This pump fills the requirements where a uniform flow of a small quantity of water under high pressure is required. When motor-driven it may be mounted on a truck and used as a portable outfit. It is provided with a knockout attachment that automatically cuts off the delivery of water, but holds the pressure when the predetermined maximum is reached. A slight drop in the pressure automatically starts the flow, which continues until the maximum is again reached. The base of the pump forms a reservoir for the liquid used in the operation.



Single-Acting Triplex Hydraulic Pump

PRINCIPAL EQUIPMENT OF THE AMERICAN CIGAR CO.'S NEW PLANT, GARFIELD, N. J.

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Boilers	Return-tubular	75-hp	Steam generators	Hand-fired, 125 lb. steam, natural draft	E. Keeler Co.
1	Engine	Ide	10x12-in.	Main units	125 lb. steam-saturated	A. L. Ide & Sons
2	Pumps	Duplex	6x4x6-in.	Boiler feed and makeup water	Automatic and hand regulated	Henry R. Worthington
1	Generator	Direct-current	50-kw.	Main unit	110-220-volt, 3-wire system	Westinghouse Elec. & Mfg. Co.
1	Heater	Combination	150-hp.	Heating feed water	Using exhaust steam	Linton Machine Co.
1	Fan	Sirocco	54-in., 25,000 cu ft. per min.	Hot-blast system	230 r.p.m.	American Blower Co.
1	Engine	Vertical, high-speed	10-hp., 6x6-in. cyl	Driving fan	230 r.p.m., 125 lb. steam	American Blower Co.
1	Air washer	Wet	70-nozzle	Washing ventilating air		American Blower Co.
1	Pump	Centrifugal	2-in.	Water for spray nozzles	1200 r.p.m. capacity, 120 gal. per hr	American Well Works
1	Motor	Direct-current	5-hp	Driving cen. pump	1200 r.p.m., 220-volt	Westinghouse Elec. & Mfg. Co.
2	Heater groups	Vento, 60-in.	20 sections each, total 640x sq.ft.	Tempering air	0 to 50 deg.	American Radiator Co.
4	Heater groups	Vento, 60-in.	20 sections each, total 1408 sq. ft.	Heating air	50 to 120 deg.	American Radiator Co.
1	Control system	Thermostat		Heating system	Automatic	Power Regulator Co.
1	Vacuum system	Donnelly		Heating system	Automatic	Jenkins Brothers
1	Pump	Simplex	6x7x8-in.	Handles condensate	10-in. vacuum	International Steam Pump Co.

The pump is built for either gear, chain or belt drive. The design is such that any one of twelve different-sized plungers may be furnished, ranging from $\frac{3}{16}$- to 1-in. diameter, advancing by increments of $\frac{1}{16}$ in. They are capable of exerting a maximum pressure ranging from 750 to 8000 lb. per sq.in. The three plungers are of the same diameter and work to the same maximum pressure. The stroke is 2¾ in. Each has a speed of 35 ft. per min. at 150 strokes, which is the rated speed, and gives the pump a total capacity of 0.11 to 1.20 gal. per min., depending upon the diameter of the plungers. The suction and discharge valves are located in the pump cylinder.

The plungers are bronze, except on the $\frac{5}{16}$- and ⅜-in. sizes, where steel is used to withstand the high pressure. The cylinders are cast *en bloc*. With the $\frac{5}{16}$-in. and the ⅜-in. plungers cylinders of forged steel are used, and for the pumps having larger plunger diameters a special bronze is used. The height over all is 35 in. and the floor space required is 16x18 in. The weight is 500 lb.

This pump is manufactured by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio.

Piping and Supports in Municipal Plant

By A. D. Williams

SYNOPSIS—Some unusual features found in the steam piping at the East Fifty-third St. Station, Cleveland Municipal Electric-Light Plant.

The East Fifty-third St. Station at Cleveland is designed to operate at 225 to 250 lb. steam pressure with a superheat of 125 to 150 deg. F., steam temperatures of 525 to 600 deg. F. being obtained when the plant was tested. The boilers are of the Stirling "Delray" type with two superheaters each, from which the steam is taken off through nonreturn valves and 8-in. steam lines to a main header divided in three sections, from each of which one of the main units is supplied.

One of the features of the steam piping is the use of flanges welded to the pipes and welded steel nozzles on the header and manifold, pipe bends being used for all changes of direction; the only castings used in connection with the live steam piping are the valves. Like most modern plants, this station is designed upon the unit system and may be operated as though it consisted of three separate plants. In one way, however, it departs from the unit design, namely, in the use of a large main steam header instead of cross-connection loops between units. This header is placed in the basement, near the wall between the boiler and turbine rooms, and is the lowest point in the steam line. It is divided in two sections by an expansion loop (Figs. 1 and 4), each section ending with a manifold tee having four side outlets from which 6-in. inverted "U" pipe bends are taken off and connect with the other section. The combined area of the bends is slightly less than the area of the header. The two manifold tees are dead-ended next to the wall by forged-steel bumped heads welded on, the opposite end being closed by a blind flange. Each section of the header is anchored midway between its ends and is supported elsewhere by rollers, as shown in Figs. 2 and 5. At each anchor point the pipe rests in a heavy cast saddle, to which it is secured by clamping rings, and bands welded to the pipe at these points assist in preventing any slipping of the rings. Each section of the header contains one Venturi Hopkinson-Ferranti stop valve by means of which the plant can be separated into three operating units.

This header, being the lowest point of the steam piping, is provided with drain outlets piped to a trap set in a pit below the floor; this provision is necessary, even with superheated steam. A stop valve is placed in each of the turbine steam leads next to the header, with the valve stem set at a 30-deg. angle (Fig. 2). Each boiler lead

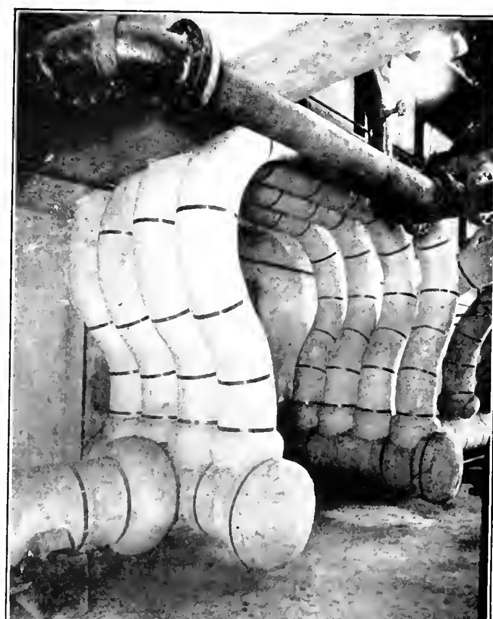


Fig. 1. Expansion Bend in Main Steam Header

is also provided with a stop valve just beyond the bend to the header, and the leads to the far side of the boiler room are supported at the boiler-floor level by floor-plates and supporting rings designed to permit free expansion in the long lead below the floor. These sliding floor-plates are shown in Fig. 6.

Fig. 7 shows the construction of two supports for the feed-water pipes—one a steel bracket anchor built up of angles and plates, the other a cast-iron saddle anchor with

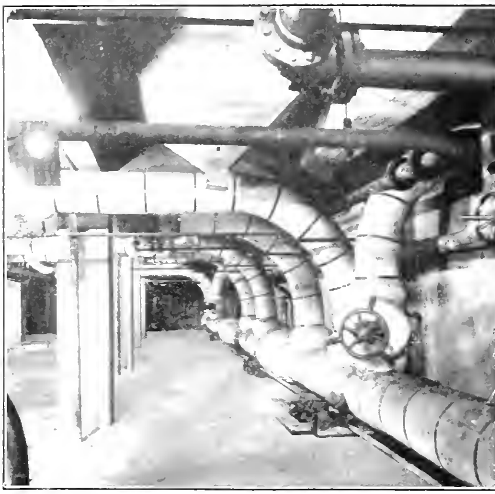


FIG. 2. SOUTH END OF HEADER, SHOWING SUPPORTS AND ANCHOR

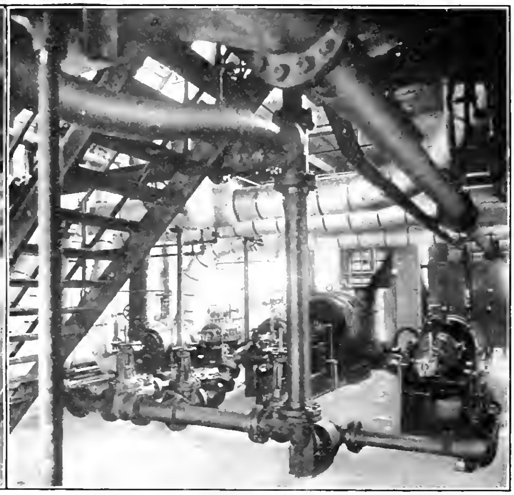


FIG. 3. PIPING AT BOILER-FEED PUMPS, LOOKING NORTH, AND NORTH END OF HEADER

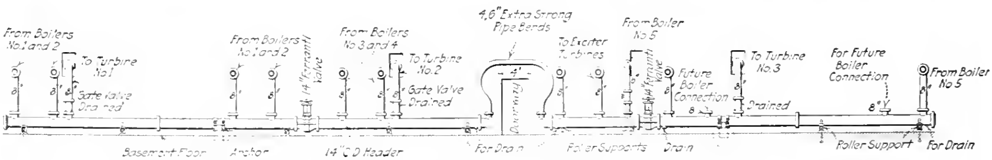


FIG. 4. ELEVATION OF STEAM HEADER, LOOKING WEST

a steel clamping plate to hold the pipe. Both of these supports are secured to the masonry by expansion bolts.

Figs. 3 and 8 show the arrangement of the boiler-feed pumps and the piping at this point. Three five-stage centrifugal pumps are installed, all being designed to operate at 1750 r.p.m. against a pressure head of 720 ft. One pump, for emergency service, is driven by a 125-hp. steam turbine and has a capacity of 350 gal. per min. The center pump has a capacity of 750 gal. per min. and is driven by a 250-hp., 440-volt, three-phase induction motor. The third pump is driven by a 125-hp. induction motor and has a capacity of 350 gal. per min. The feed-water supply is drawn from the hotwell into which the condensate from the surface condensers is discharged, a sufficient head being maintained to cause the water to flow to the V-notch meter through a 12-in. supply line. All of the pumps draw on a suction header to which the water from the meter flows through an 8-in. line, and an 8-in. bypass is provided around the meter. From the pumps the water enters a pressure header from which lines run to both economizers. Two bypass risers are provided which connect to the boiler-feed loop. The pressure end of the boiler-feed system is arranged so that there are two possible routes for either hot or cold feed water between the pumps and the boilers.

The use of electrically driven auxiliaries for the condensers, induced draft and forced draft, and for the stoker drive and boiler feed, eliminates a large amount of small steam piping and exhaust lines. All of the piping under high pressure is extra strong lap-welded medium-steel with cast-steel fittings. The low-pressure piping is of standard-weight wrought iron, cast iron or, as in the case of the free exhaust line, spiral riveted pipe. Each turbine is connected to the free exhaust line by a 24-in.

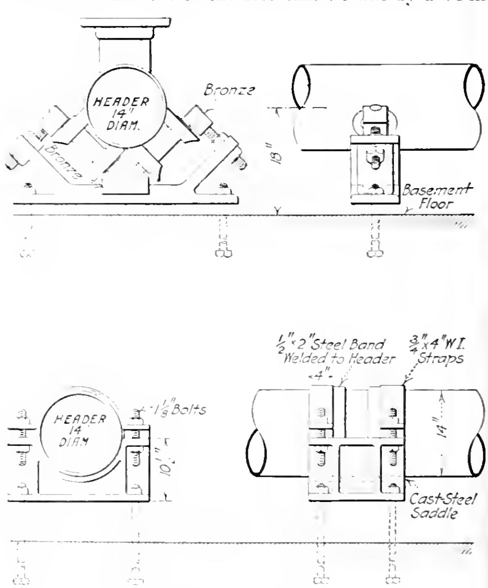


FIG. 5. ROLLER SUPPORT AND ANCHOR BLOCKS FOR MAIN STEAM HEADER

free exhaust valve on the condenser. A 24-in. header is located in the turbine-room basement, just below the floor, and a riser at the center of this header passes up through the floor, then diagonally through the wall into the boiler room and ends just above the roof. This riser,

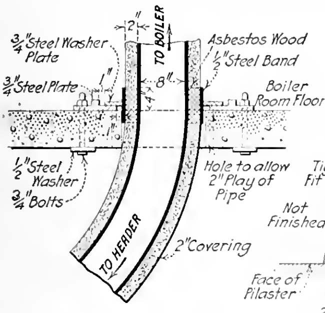


FIG. 6. SLIDING FLOOR PLATES FOR BENDS LEADING TO BOILERS NOS. 1, 3 AND 5

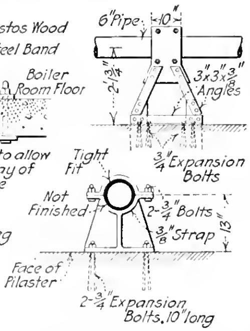


FIG. 7. CAST-IRON AND STEEL ANCHORS FOR 6-IN. PIPES

which may be called upon to carry the exhaust from three 5000-kw. turbines, is the same size as the header and the free exhaust valves.

The nominal overload steam requirements of the turbines is about 70,000 lb. per hour. This is brought to the turbine through an 8-in. pipe, the velocity of flow being about 117 ft. per second. In the exhaust line this amount

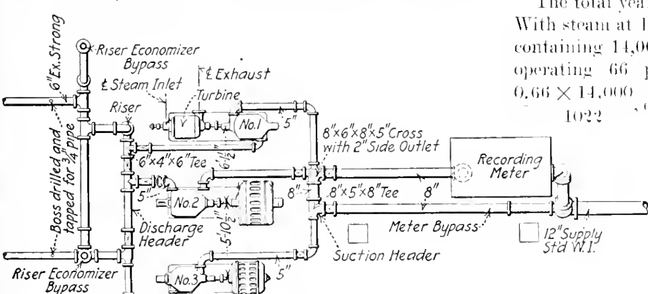


FIG. 8. PLAN OF PIPING AT BOILER-FEED PUMPS

of steam could be carried with a velocity of about 110 ft. per second, at 17 lb. absolute pressure. The reduction in cost of the pipe and covering for small sizes is considerable, so that for economic reasons the pipe should be the smallest size that will pass the steam with the maximum permissible friction and radiation losses.

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TYPICAL CONDENSER DATA AND PERFORMANCE

Horsepower	Steam, Lb. per Hr.	Cooling Surface, Sq.Ft.	Condensation Rate in Lb. per Sq.Ft.	Actual Vacuum 30-in. Bar	Circulating Water, Deg. F.	Hot-well Temp., Deg. F.
5,800	87,000	3,282	26.5	26.8	44	110
12,000	180,000	8,000	2.5	27.7	72	104
12,000	180,000	8,636	20.8	28.95	49	69
12,000	174,000	8,440	20.6	27.2	53	98
22,000	340,000	16,820	20.25	28.8	54	78
27,000	418,500	21,600	19.375	28.85	57	76
17,000	240,000	9,000	26.7	28.55	45	78
2000 kw.	28,800	3,000	9.6	28.1	75	95
5,300	80,000	4,400	18	{ 27.3	44	111
				{ 26.75	84	106
2,500	46,000	1,300	35.4	27.3	54	101
....	15,000	300	50	23½	60	120

Costs in Small Industrial Power Plant

By C. W. THAYER

When an isolated power plant can be operated at a profit in a district where the hydro-electric interests are well developed, the figures should prove important.

In the present instance, the plant consists of two horizontal return-tubular boilers, with an aggregate rating of 225 boiler horsepower, two steam pumps, one power pump, an open feed-water heater, a draft regulator and the usual small accessories. The total value of this equipment is $4100. The building is valued at $3000, the 110-ft. chimney at $1200, the boiler and accessories foundations at $150, and the land at $1000.

The fixed charges on the boiler plant are as follows:

Interest at 5 per cent. on total investment of $9450..	$472.50
Taxes at 1 per cent. on total investment of $9450....	94.50
Insurance on building and equipment..............	15.00
Special boiler insurance...........................	36.00
Depreciation on building and chimney (1.5 per cent. on $4200)	63.00
Depreciation on equipment (6 per cent. on $4250)....	255.00
Repairs on building and chimney (1.5 per cent. on $4200)	63.00
Repairs on equipment (6 per cent. on $4250)........	255.00
	$1254.00

The operating charges are as follows:

Engineer, 70 per cent. of time in boiler plant (70 per cent. of 52 weeks), at $22 per week.............	$800.80
Night fireman, 30 per cent. of time (30 per cent. of 52 weeks), at $18 per week....................	280.80
Sunday man, 52 days at $2.50......................	130.00
	$1211.60
Supplies	70.00
Water	100.00
Coal (1100 tons at $4.20, delivered short tons)......	4620.00
	$4790.00

The total yearly charge for the boiler plant is $7255.60. With steam at 140 lb. gage, feed water at 200 deg. F., coal containing 14,000 B.t.u. per lb., and a boiler and furnace operating 66 per cent. efficiency, the evaporation is

$$\frac{0.66 \times 14,000}{1022}$$

, or approximately 9.04 lb. water per pound of coal. The figure, 1022, is the B.t.u. added to the feed water to produce a pound of steam. The cost of evaporating 1000 lb. of water is 36.5c. which is found as follows:

$$\frac{7255.60}{1100 \times 2000 \times 9.04} \times 1000 = 36.5$$

As the demand for steam increases, the evaporation cost will decrease.

The power plant consists of the following items with their corresponding valuations.

Land valued at	$1000
Building valued at	1150
Engine foundations	450
Slide-valve compound engine, 150 hp., direct-connected to a 125-kw. direct-current generator..........	2800
Generator (125 volts)	1500
Engine piping and separator.....................	700
Switchboard	1000
Apparatus and tools............................	250
Automatic lubricator and filter..................	210
Total	$9060

The engine-plant fixed and operating charges are:

Interest at 5 per cent. on total of $9060..............	$453.00
Taxes at 1 per cent. on total of $9060................	90.60
Insurance on buildings and equipment..............	15.00
Special flywheel insurance.........................	24.40
Depreciation on building, etc. (1.5 per cent. on $1600)	24.00
Depreciation on equipment (4 per cent. on $7460)..	298.40
Repairs on building, etc. (1.5 per cent. on $1600)....	24.00
Repairs on equipment, etc. (4 per cent. on $7460)....	298.40
	$1227.80
Labor (30 per cent. of engineers' 52 weeks at $22)....	343.20
Supplies (oil, waste and fuses).....................	200.00
	$1771.00

The engine is operated 300 days for 9 hr. a day, and switchboard records show the average load to be 140 b.hp. A recording flow meter shows an average of 32 lb. of steam per b.hp.-hr. The steam cost is then

$$\frac{300 \times 9 \times 140 \times 32 \times \$0.365}{1000} = \$4415.04$$

This charge for steam of $4415.04, plus the $1771 for fixed charges, labor and supplies, gives a total charge of $6186.04 for 378,000 hp.-hr., or a cost of 1.63c. per hp.-hr.

In the three winter months all the exhaust steam from the engine is used for heating the plant. As this exhaust will have at least 85 per cent. of the heat units available that are contained in the equivalent weight of saturated high-pressure steam, it is fair to credit this amount to the power plant; hence

$$\frac{\$4415.04}{4} \times 0.85 = \$938.20$$

This reduces the annual cost from $6186.04 to $5247.84 Using this basis, the cost per horsepower-hour is 1.38c.

Eckel Hydrostat Feed-Water Regulator

The Eckel hydrostat for regulating boiler-feed water is illustrated herewith. Fig. 1 shows the device attached to a boiler and piped to a feed pump. The details of construction are shown in Fig. 2. The only moving parts

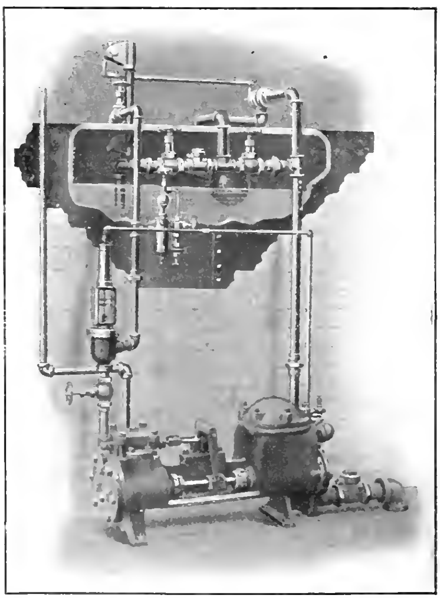


Fig. 1. Pipe Connections of Hydrostat and Pump

in the boiler are the float, tested to 300-lb. pressure, and the rod connection, which is actuated by the float lever as the water level in the boiler rises or falls.

The vertical rod is incased in the upright supporting stand, and its movement is transmitted to a lever in the casing at the top and on the outside of the boiler shell. This lever is attached to a rod which passes through a stuffing-box and by a series of levers operates a control valve in the feed pipe.

The feed pump is fitted with a governor, controlled by the pressure from the water end of the pump. When the valve in the feed line is partly closed, owing to the

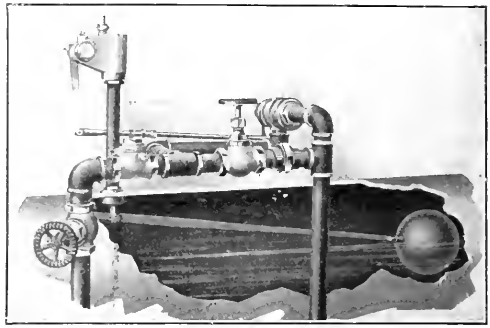


Fig. 2. Hydrostat with Series of Boilers

height of water in the boiler, the pressure in the discharge pipe is increased and this pressure is transmitted to the regulator, partly closing it, and slowing down the pump. Fig. 2 illustrates the type of hydrostat used on boilers set in series, where more than one boiler is fed by the same pump.

The hydrostat used with a single boiler controls the

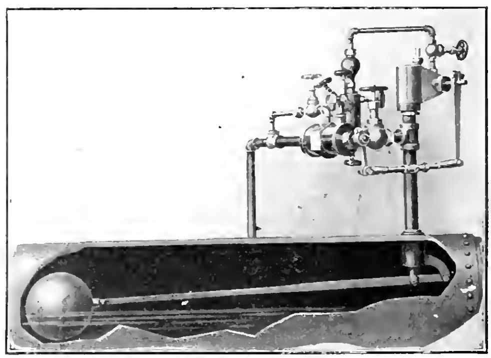


Fig. 3. Hydrostat Used with Single Boiler

pump speed and no pump governor is used in connection with it, as it is a governor as well as a hydrostat.

The control valve is so designed that dirt cannot stop it from closing, and it works like a shear and is supposed to cut off any matter that might lodge between the ports. The valve does not wire-cut by the passage of the water; the valve is sectional and may be easily taken apart.

This regulator, which is made by the Eckel Hydrostat Co., 458 Mt. Elliott Ave., Detroit, Mich., can be used on any steam boiler.

It Is Contended that fuel can be saved by using higher steam velocities in pipes; the limit for safety with reciprocating engines is 82 to 98 ft. per sec. The Berlin Electricity Works Co. carried out experiments and obtained considerable saving in fuel by eliminating pipes which had been put in to reduce the fall of pressure.—Exchange.

Return Traps for Feeding Boilers

By K. M. Gilbert

SYNOPSIS—Advantages and steam consumption of traps. Explanation of the principle of operation.

Steam traps have been known for many years as a means of feeding boilers, but it seems that they have not been used in small power plants as widely for this purpose as their merits would warrant. For small boiler plants up to 300 hp. a steam trap is an economical and satisfactory means of feeding hot water into a boiler. A good trap requires little attention and no lubrication; it has no piston or piston rods to pack, and but few wearing parts.

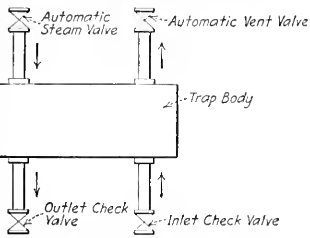


Fig. 1. Diagram of Elementary Trap

For these reasons the repair charges are low—much lower than for a feed pump. For a 100-hp. boiler at full load, a steam trap for boiler feeding would require about twenty pounds of steam per hour; a small duplex steam pump for the same purpose, about one hundred twenty-five pounds. The use of a trap instead of a feed pump would at this rate save 100 lb. per hour, which at an evaporation of 7 to 1 means 14 lb. of coal per hour, or 140 lb. per day for each 100 hp.

There are two general classes of traps, the return and the nonreturn. The return trap is used when it is desired to elevate or discharge the water against a head or pressure equal to or greater than that of the water entering the trap, as for feeding boilers or draining a vacuum system. A return trap has an automatically operated live-steam valve and usually a vent valve, both of which are operated by the action of the trap when sufficient water has entered.

A nonreturn trap has no live-steam connection, and for this reason it cannot discharge its contents against a head any greater than that of the water entering it.

There are several types of traps which, if named according to the method of operating, the valves may be called tilting, bucket, float, expansion, and differential. These various types have their advocates, but from the writer's experience of several years he has found that the tilting trap has given the best service. All of its working parts are accessible and within the sight of the engineer, who can tell at a glance how the trap is working.

While the methods of operating the valves of the several traps vary, the principle of operation is the same for all types and, for the benefit of the young engineer, can be explained by aid of Fig. 1. The drip or feed water for the boiler enters the body of the trap through the inlet check valve. When sufficient water has entered, the operating mechanism of the trap is so arranged that either the weight of the water, a float valve, or a bucket, etc., automatically closes the vent valve and at the same time opens the live-steam valve. The steam pressure then acts on the surface of the water in the trap, the inlet check valve closes and the outlet check valve opens, enabling the steam to force the water out of the trap. When the trap is nearly emptied the steam valve is closed and the vent valve automatically opened. The pressure in the trap body is reduced to atmospheric so that the drip water can enter and again fill the trap. From this explanation it should be readily seen that the steam consumption for each discharge of the trap is about equal in volume to that of the trap reservoir.

Fig. 2 shows the arrangement of piping, traps and feed-pump connections to two return-tubular boilers. The feed pump is for use while examining or repairing the traps. The trap discharging into the boiler must be placed about four feet above the water line in the boiler, then when the steam is admitted to the trap this head is sufficient to overcome the friction of the piping and check valves so that the trap is quickly discharged. In all cases the water must flow into the feed trap for, unlike a pump, it has no power to raise water by suction. When by the pressure in the system the water cannot be raised to the feed trap, another trap must be employed to do this work. The low-pressure trap (Fig. 2) is connected to discharge the low-pressure drips into the feed trap. Its action is the same as the feed trap, and the use of the live-steam connection makes it possible to raise the water.

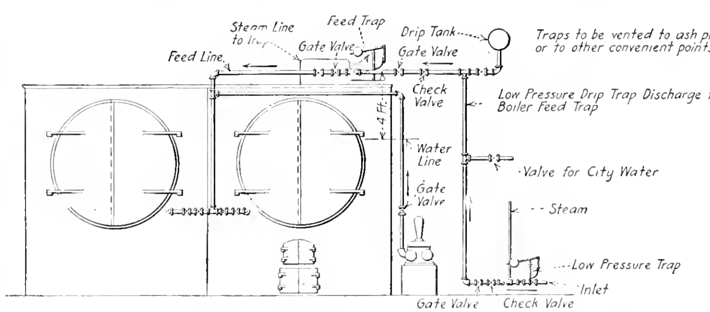


Fig. 2. Piping for Tilting-Trap Boiler-Feed Installation

The pipe connections to and from all traps should be sufficiently large and free from numerous turns. The pipe connections to nearly all traps are too small, and the inlet and discharge pipes should be one or two sizes larger than the trap connections. The inlet pipe line should slope toward the trap, and the outlet should slope downward in the direction of the flow of water to the boiler. An air chamber on the discharge line will prevent the noise and shock which sometimes occurs from water-hammer.

The check valves should be of the swing type and the others of the gate type. The live-steam connection must be made direct to the boiler shell or as close as possible, so as to have the full steam pressure available for operating the trap, as a pound difference in pressure between the trap and the boiler may prevent satisfactory operation and reduce the capacity of the trap. The packing used around the valve stems should be of soft material and well lubricated. Most of the tilting-trap troubles come from using a hard asbestos packing which in a short time becomes hard and binds the stems. The packing should be braided and well lubricated with graphite.

Slippage of Reciprocating Pumps

By T. B. Hyde

SYNOPSIS—In view of the many different expressions relative to pump slippage which have lately appeared in Power, *the following article will be of much interest to the many concerned with the subject. The volume of slippage depends upon the discharge and suction pressures, condition and tightness of valves and plungers or pistons.*

Slip is a "dead" loss of power. The useful work done by a reciprocating pump is measured by the amount of liquid pumped, multiplied by the head pumped against. This is less than the indicated work of the pump cylinder by an amount equal to the slip. Slip is therefore defined as the difference between piston or plunger displacement and the actual volume of pumpage expressed as a percentage of the former.

Where the pumping unit is large slip is usually closely watched and kept at a minimum, but the same cannot be said of many smaller pumps, particularly those used for boiler-feeding purposes. As an example the writer recently noted a feed pump running with 80 per cent. slip; in other words, its displacement was five times its pumpage; its useful horsepower, represented by water delivered to the boilers, 4.20; its actual water horsepower, four times that, say, 17. The steam consumption, or water rate, of these small duplex pumps is seldom less than 120 lb. per water horsepower-hour, and usually higher. Using this conservative figure for an assumption, this pump was using 17 × 120 = 2040 lb. steam per hour, of which 80 per cent., or 1632 lb. (47 boiler hp.), was spent for slip. A feed pump can be handled nicely on 15 per cent. slip, so that there was a clear waste of 38 boiler hp., or in money, roughly, thirty cents per hour. The main units were noncondensing; it was summer and there was an excess of exhaust steam, so there was no justification of this waste.

Slip is greater at low pump speeds than at high. In order to understand this clearly we must differentiate between per cent. slip, or "slip" as it is called, and actual volume of slip. The latter is the difference between displacement and pumpage and is reduced to per cent. slip by dividing by displacement. The volume of slippage depends upon discharge and suction pressures, condition and tightness of valves and plungers or pistons, as the case may be. It may be likened to a leaky globe or throttle valve; the greater the pressure, the greater the amount of leakage; the greater the amount of opening, the greater the amount of leakage. Wherefore, with a given pump, with valves and pistons in a given condition, the actual volume of slip may generally be said to be independent of speed; a function of discharge pressure and time only. But in reducing to per cent. slip, we divide this constant amount by the displacement, which varies directly with speed. Hence, with high pump speed (large displacement) per cent. slip will be low, and *vice versa.*

Slip may be as high as 100 per cent., as is the case of a pump working against a closed discharge valve or a fire pump drifting along at two or three revolutions per minute, maintaining a constant pressure on a sprinkler system. Slip may be as low as zero or even be a negative quantity. In the latter case the pump is actually delivering an amount of water greater in volume than the displacement of the pump itself. When this occurs it is due to the rise in pressure in the suction line when the flow is suddenly checked, forcing water through both suction and discharge valves and into the discharge line. This action is similar to the hydraulic ram, where the velocity of the water being suddenly checked, it is changed into pressure sufficient to force a small quantity of water into the discharge line against a pressure considerably greater than the supply head. This negative slip occurs only under a combination of favorable conditions, among which are high velocity of water in suction pipe with slight suction head, low discharge pressure and tight valves. To produce negative slip the amount of water passed through by this "hydraulic-ram" action must be sufficient to more than balance the normal slippage through the valves.

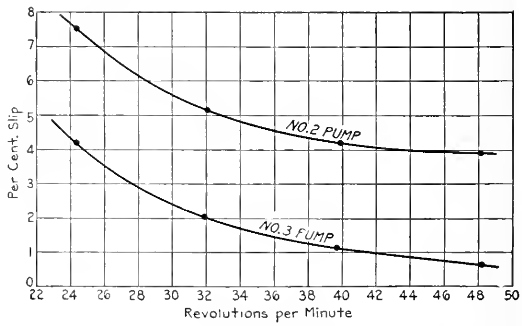


Fig. 1. Slippage-Test Results of Large Pumping Engines

Fig. 1 shows the result of slip tests on two large cross-compound steam-driven flywheel pumping engines. The pump plungers of each unit have a displacement of 306 gal. per revolution. These tests were conducted with considerable accuracy, the water being measured by a venturi meter in the pump discharge line. The discharge pressure was 40 lb. per square inch gage; suction head practically zero. In these pumps, when valves are in good condition negative slip is frequently found at the higher speeds.

Fig. 2 shows a slip test on a 12x7x12-in. steam duplex feed pump. Incidentally, this test was made to calibrate

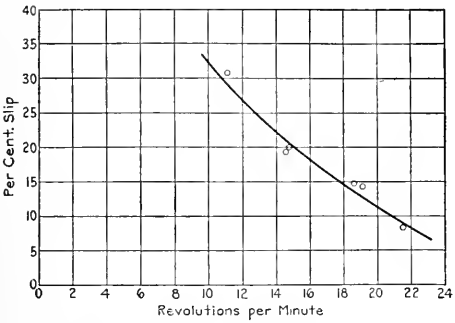


Fig. 2. Slippage Test on 12x7x12-In. Duplex Pump

the pump, so that a revolution counter could be attached and the pump used as a boiler feed-water meter to measure the station boiler load. Such a slip test is simple and can be made by any engineer in the following manner, without any extraordinary apparatus: Blank off the regular discharge line and pipe the discharge to weighing barrels or, as was done in this case, to a large tank that had been previously measured. Old fire hose was used for piping. Put a throttle valve in the discharge line near the pump and place a pressure gage between the pump and this valve. At whatever speed it is desired to run the pump, maintain the discharge pressure, by means of this valve, the same as that against which the pump normally works. Two other conditions—suction head and water temperature—should be maintained the same, although they are of lesser importance than pressure and speed. In the test referred to, these were taken care of by pumping from the regular feed-water heater through the regular suction line. Live steam should be admitted if necessary, to maintain the normal feed-water temperature. The pump may be calibrated at a single speed, which should be that at which it normally runs, or if desired, the calibration may be extended over a range of speeds, but no comparison can be made between test and running conditions unless both pressure and speed are the same. For accuracy suction head and temperature should be the same, although any change in either, sufficient to introduce any serious error in results, would usually make itself noticeable by hammering of the pump, indicating that the pump was getting either vapor or air.

Duplex steam pumps tend to "short-stroke" at low speeds. Strictly, this should not be charged to slip, for it is neither a waste of power nor of steam. In the above test, however, is was charged to slip, in order that the results of the slip test might be applied to the readings of the counter to obtain the amount of boiler feed. This method of measuring boiler feed can be recommended only for places where suitable meters are not available.

Just for Fun

[More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.]

We are pleased to give you the following, which we believe is good enough to publish in Power

A new salesman was sent out to sell a steam engine. The customer advised him that he would like an engine that would run both over and under. The new salesman explained to him that all he would have to do would be to turn the throttle to the right to make it run over and to the left to make it run under.—*I. N. Beeler, Syracuse, N. Y.*

In a certain felt factory static electricity caused trouble at the cards. I sent an electrician to the plant, instructing him to arrange a "comb" close to the drive belt and connect it by wire to a gas pipe, water pipe, or any conductor that ran to ground. Going to the plant afterward to see if the trouble had been completely removed, I found that instead of being connected to a pipe the wire was run to a pail on the floor, which was partly filled with water. The intention, I was told, was to empty the pail when it became filled with electricity.

In another plant I noticed a pipe with a valve connected to the steam space and running down beside the boiler and through the setting. The engineer opened the valve occasionally. Thinking it might be some new smoke-consuming device, I opened the furnace door to see how it operated and discovered that the pipe was connected to a small bag on the bottom of the boiler. I asked the purpose of the pipe and was told that the mud and scale had a tendency to settle in a bag on the bottom of the boiler and that by means of the pipe he could blow steam into the bag and displace the scale.—*R. McLaren, Medicine Hat, Alta.*

At one time along my trail of bygone experience, I hired out as engineer of a grist mill that was located in a region wherein capable engineers were by no means abundant.

I arrived in the village at supper time on the day before I went to work, and didn't have much of a chance for a preliminary look around. In the morning, when I had everything in readiness, as I thought, for starting the engine and was about to turn on the steam, the colored man who looked after the place at night handed me a stout bludgeon, with the remark: "Heah am yo' stahtah, Boss. Yo' kaint staht dis heah injine 'thout yo' stahtah."

"Starter for what?" I inquired.

"Why, fo' dis heah twadlash," he explained, as he indicated the head-end valve arm.

Sure enough! It wouldn't stay hooked up on the head end at starting, and my predecessor had apparently accepted it as a matter of course that the only thing to do was to keep prying the valve open until the governor rose to a running position. Of course, it was simply a matter of adjusting the safety cam on that end. This I quickly attended to.

At sight of the engine starting off unaided by the hickory stand-by he had offered me, my Senegambian mentor seemed transfixed with the wonder of it, while his ebony visage took on an expression of dumb amazement.

"Laws sakes, Boss!" he exclaimed when he recovered his breath, "yo' sho done chahmed away dat hoodoo, whatevah yo' done!"—*M. D. Conroy, St. Louis, Mo.*

Storage Batteries for Handling Peak Loads

By Everard Brown

SYNOPSIS—Improvement of load factor and plant economy as well as regulation, particularly in the case of hydro-electric generation, where storage batteries are employed to assist on the peaks of the load. Typical load curves show this for different classes of service.

In large central stations for electric power and railway service the use of storage batteries is common. Because of their rather high initial cost, however, this use is somewhat restricted to the larger power plants, although there are some installations among the smaller stations also.

The primary object of a storage battery in electrical-railway service is to relieve the generating apparatus of the larger fluctuations in load by taking care of the peaks that occur at certain periods of the day, and also to act as a reserve in case of a breakdown. By relieving the station of such fluctuations the generating units are free to operate at a steady and, consequently, an economical load. Moreover, storage batteries discharging on the peak loads

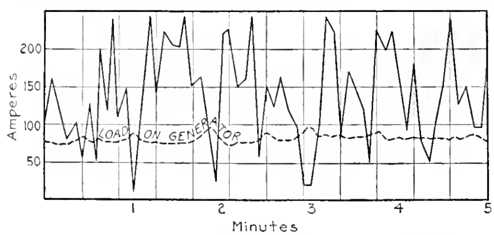


Fig. 1. Battery in Power House—Railway Service

and taking a compensating charge during the period of light load will raise the load factor, thereby improving the economy of the plant; and, by taking slight peaks on an increasing station load, they retard the time of starting additional engines. Figs. 1 and 2 show the fluctuations and peak loads over short periods in railway service as taken care of by a storage battery. In both it will be noticed that the battery is discharging much more than it is being charged. Such a condition occurs, naturally, at times when the traffic begins to increase or lights are put on, but not to such an extent as to warrant the starting up of another generating unit.

Heavy line batteries or battery substations are frequently used on railway and district lighting systems to relieve both the power station and the feeder system, but principally the latter, at times of high peaks. At other times they are used to regulate the voltage and care for the variations in the current. Without batteries the peaks can be taken care of only by extra generating apparatus at the main power station and extra feeders to the center of the load district. The substation battery, being located at or near the point of heavy load, eliminates these requirements and relieves the system of fluctuations, so that the cars or the lights or both, as the case may be, can operate at a steady voltage. The operation of a railway line battery taking fluctuations is indicated by Fig. 3, which shows that current was absorbed and discharged by the battery at very short intervals. In this

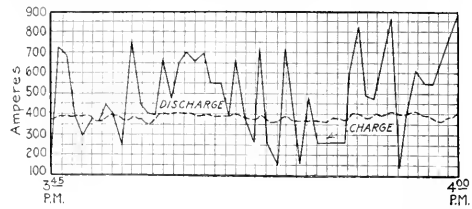


Fig. 2. Battery in Power House—Railway Service

case, however, the discharge is fairly well compensated by the charge.

In rotary-converter substations storage batteries may also be used to advantage. The installation of sufficient storage capacity in such a substation will relieve the converter of current fluctuations, so that the load on the transformers, high-tension transmission lines, and the alternators, engines and boilers in the generating station

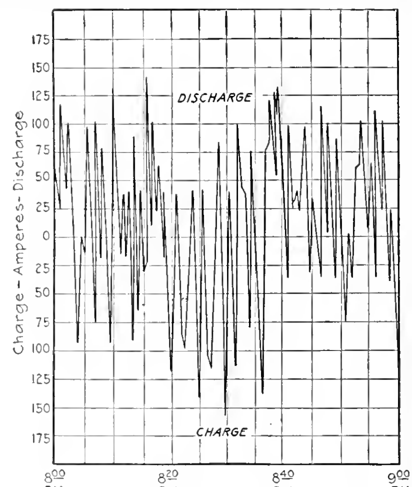


Fig. 3. Railway Line Battery Taking Fluctuations

may be maintained practically constant. An illustration of this may be seen in Fig. 4. The line pressure is maintained between the limits of 450 and 550 volts and is indicated by a nearly straight line. In this curve it will be noticed that the greatest demand upon the substation is between the hours of 6 and 10 in the morning and 5 and 9 in the evening. This is typical of street-railway service. It will be seen that the greatest amount of charging is done between 9 p.m. and 6 a.m., at which time the load is the lightest. Some charging is also done from 10 a.m. to 5 p.m., showing that the power-generating capacity is in excess of the load requirements during this period.

In hydro-electric plants good voltage regulation is often a difficult matter. At full loads a waterwheel usually

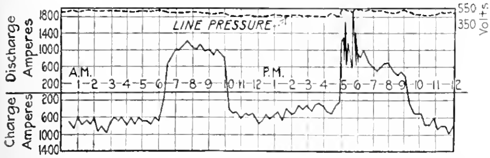


Fig. 4. Railway Line or Substation Battery Taking Fluctuations and Peak Loads and Regulating the Voltage

takes all the effective water that can pass through its opening at a given head, consequently an overload means a drop in speed. The load variation, moreover, is generally so rapid that the inertia of the water in the penstock prevents satisfactory speed regulation, regardless of how sensitive the governor may be or how ample the wheel capacity. These troubles can be largely overcome by

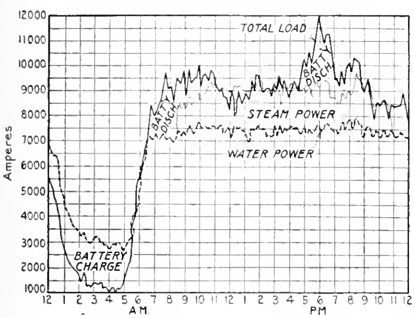


Fig. 5. Battery at Railway Power House Taking Peaks

the use of storage batteries. It might be said, in fact, that the introduction of such a battery is really equivalent to increasing the capacity of the plant in the same ratio that the peak removed bears to the average load. Results of such an installation may be seen in Fig. 5. In this station as much of the power as possible is generated by water and a steam plant in connection with a storage battery helps out on the peak. From midnight till 5 a.m., it will be noticed, the hydraulic generator had a surplus of capacity above the load requirements, so that some charging of the battery takes place. Then from 6:30 to 8:30 a.m. the battery helps the water power and defers starting up the steam plant about two hours.

For small light and power plants of limited output, Figs. 6 and 7 show what the storage battery will do. In such plants the day load is usually light; therefore, a comparatively small battery will supply current for a large part of the time and the battery can be charged in the evening or early morning, when the plant is in operation. In this manner a day service can be maintained at little expense for labor and with a materially decreased operating cost per unit of output. In addition to this there is the advantage, common to all kinds of power stations, of having an extra source of power ready in case of demand, thus insuring good regulation of the voltage.

In considering the installation of storage batteries the room should really be in a separate building, if possible, away from the rest of the equipment, and in order to keep down the temperature and to free the room from acid spray it should be well ventilated. In some instances it may even be necessary to resort to artificial ventilation by means of a fan or blower if the battery does considerable peak-load work and requires almost continuous charging at certain hours. As the gases given off during the charging of a battery form an explosive mixture if confined, this need of proper ventilation is important, as is also the keeping away of any exposed flame at such a time. In cold climates it is sometimes necessary to heat the battery room in order to obtain the maximum capacity.

In charging a battery the rise in voltage is quite gradual except near the beginning and the end of a charge, when it becomes more rapid. When fully charged the

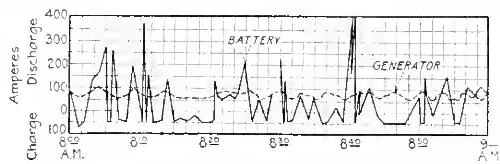


Fig. 6. Battery Taking Fluctuations of Motor Load—Small Plant

color of the positive plates varies from a reddish brown to nearly black and the negative from a pale to a darker slate color. The negative plates, however, are always lighter in color than the positive. Excessive discharging should always be prevented if possible, as it has a tendency to cause excessive heating of the electrolyte and disintegration of the plates. This disintegrating as well as buckling of the plates and sulphating are the most serious troubles incident to the use of a storage battery, but these can be avoided to a large extent by proper attention. Man-

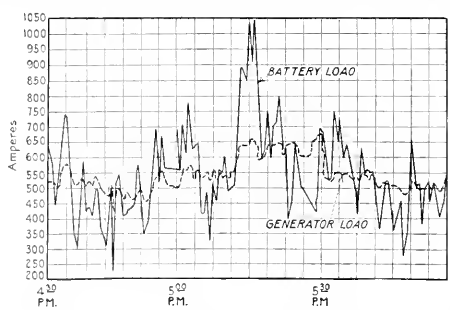


Fig. 7. Battery Taking Fluctuations at Railway Power House of Limited Output

agement of a battery installation requires more experience and care, however, than the handling of electric generators, because of the chemical actions which occur in the former and which are more difficult to determine and correct than mechanical or electrical difficulties encountered in the generator. As for depreciation charges, they are somewhat higher, averaging about 8 to 10 per cent.

Safety-First Water Column

The high- and low-water alarm column, Fig. 1, has the outside appearance of an ordinary safety water column. It differs, however, in that it has no floats. Instead, it has two solid metal weights hung one above the other by bronze rods (Fig. 2) from the opposite ends of two bronze levers which rest on a bronze knife-edge fulcrum.

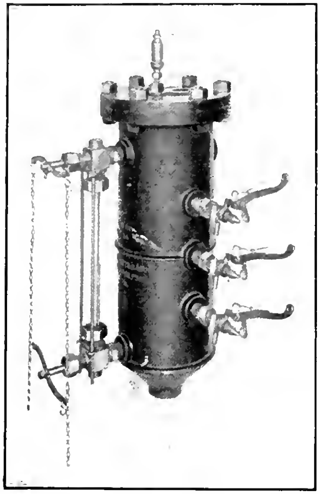


Fig. 1. Safety-First Water Column

The two weights are so designed that the bottom one is the heavier when both weights hang in steam or when both are submerged, as would be the case at extreme low or high water; the top one is the heavier when the bottom one only is submerged, as would be the case when the water level is between the top and bottom gages.

One of the bronze levers is connected to the alarm whistle valve by a knife-edge bearing. The valve and seat are made of monel metal.

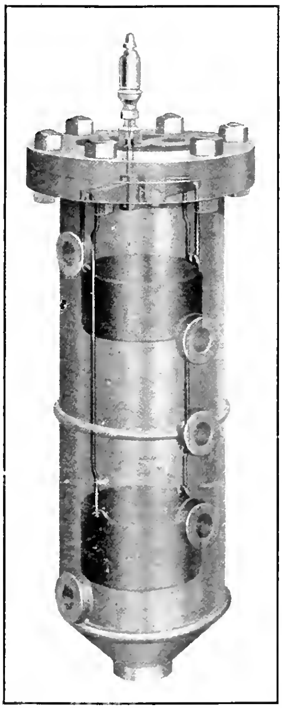


Fig. 2. Arrangement of Weights and Levers

Referring to Fig. 2, it is evident that when the water stands at any level between the top and bottom gages, the bottom weight will be submerged and the top one will hang in the steam space. Under these conditions the upper weight will weigh more than the lower one, and will hold the whistle valve closed.

Should the water fall below the bottom gage, the lower weight will weigh more than the upper one, which will rise and open the whistle valve, thus giving the low-water alarm.

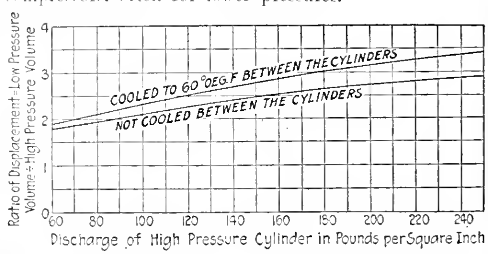
Should the water rise above the top gage, the upper weight will weigh less, and the lower one will overbalance it, which causes it to rise and open the whistle alarm for high water.

This appliance is manufactured by the Engineering Company of Philadelphia, Harrison Building, Philadelphia, Penn.

Cylinder Ratios for Air Compressors

By F. W. Salmon

Many steam-driven air compressors have to operate at speeds differing greatly from hour to hour to suit the demands for air. This makes it desirable to choose the cylinder ratios of the two-stage air ends with great care, so that the machine may operate steadily and smoothly without danger of stopping on a dead center even at the lowest speed, for naturally, a two-stage compressor will be chosen in most cases to secure economy in power for pressures of 80 lb. or higher, and in the case of large compressors, often for lower pressures.



Ratios with and without Intercooling

The curves show the volumetric ratios required for a two-stage air compressor taking dry air at atmospheric pressure at sea level and delivering it from the high-pressure air cylinder at pressures of 60 to 250 lb. gage, both cooled and not cooled between the cylinders. Moreover, they are calculated to give the same power in the high-pressure cylinder as in the low-pressure.

In various books on compressed air, such as that by Frank Richards, Kent's "Mechanical Engineers' Pocket-Book," and Suplee's "Mechanical Engineers' Reference Book," are given tables showing the horsepower required (neglecting friction) to compress and deliver one cubic foot of free dry air per minute at atmospheric pressure, to given discharge pressures, both isothermally (perfectly cooled between the cylinders and during the compression) and adiabatically (not cooled at all). This given horsepower has been divided equally between the two cylinders and the mean effective pressures calculated for each, as well as the resulting intercooler pressure, which may be taken as the initial pressure for the high-pressure cylinder. Hence the volumetric displacement to meet these conditions could be readily calculated for several of the pressures given, including the 60-lb. and the 250-lb., and a smooth curve drawn through the points so obtained on the chart. This covers the range of pressures needed in over 95 per cent. of the air compressors sold, and it can be read close enough for all ordinary work, because in commercial practice air compressors are rarely made to bores of fractions of an inch.

Practically all air compressors operate between the limits shown by the two curves. Even in a single-stage compressor the air is cooled somewhat during compression, and yet in the best two-stage machine it is never quite as perfect as isothermal compression; hence in practice it is wise to choose the nearest commercial cylinder sizes that fall between the curves shown in the chart. Of course, one should consider the actual volume of air displaced from each cylinder rather than the piston displacement, as the cylinder ratio depends upon the volumetric efficiency of each cylinder, which is rarely the same for both the high- and the low-pressure cylinders. This is illustrated in the following example:

Assume, that in order to deliver the air required, a 24-in. low-pressure cylinder will be used having a 30-in. stroke and giving a volumetric efficiency of 0.90 for this stroke with the type of valves used. The size of the high-pressure cylinder is desired that will discharge air at 100 lb. gage, with the same stroke, but with a different type of valve which will probably give a volumetric efficiency of 0.85.

Running up the 100-lb. line the best cylinder ratios are found to be 2.11 not cooled or 2.30 cooled. As both cylinders are to have the same stroke, only the areas have to be considered; hence, if A represents the area of the low-pressure piston in square inches and a the area of the high-pressure piston in square inches, then,

$$a = \frac{A \times 0.90}{constant \times 0.85}$$

or

$$a = \frac{452.4 \times 0.90}{2.30 \times 0.85} = 208\ sq.in.;$$

say 16¼ in. diameter (if fully cooled), and

$$a = \frac{452.4 \times 0.90}{2.11 \times 0.85} = 227\ sq.in.;$$

say 17 in. diameter (if not cooled).

Thus, there is not much difference, and as explained above, actual practice will lie between these two curves. Of course, if the cylinders are of different strokes, their volumes must be considered instead of their piston areas.

Recedence and Pressure Readings from Submerged Pumps

By G. B. Covington

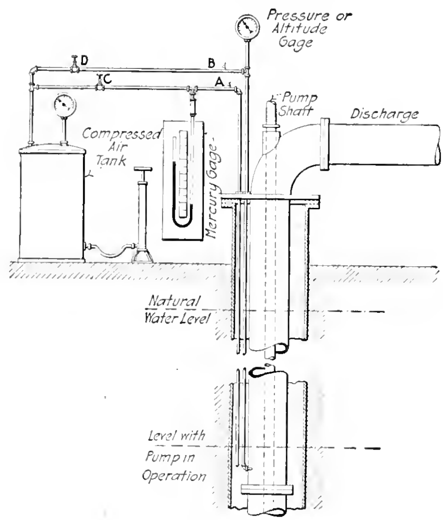
The recedence in level of a deep well, due to its being pumped at various rates, furnishes reliable data as to its capacity. The method of determining the differences in level by an apparatus which may be either constructed as a permanent fixture or made up as a "portable," may be of interest, as in most cases no space is available in the well casing in which to lower a float or other device by which to gage the levels.

For determining the recedence a tube A, shown in the sketch, is let down the well outside the discharge casing, so that the submerged end will be several feet below the natural water level, which, if not known, may be ascertained by experiment.

The tube may be of ¼-in. pipe made up as shown, with valve C for air control and a mercury gage tapped in between it and the submerged tube. Air must first be compressed in the tank (if no service supply is convenient) to a considerable pressure in excess of that due to the submergence of tube A, which may be determined in the following manner: Upon opening the valve C and upon closing the same after a maximum pressure is indicated, the mercury column should recede an amount which will represent the friction of the air in the tube at the rate at which it has been admitted. The static reading is then noted.

Upon starting up the pump or air lift, the operation is repeated, and the difference in the two static readings represents the recedence of the well level. These may be reduced to feet and inches and plotted against "pump delivery."

A similar device for determining the total head under which the pump operates is indicated at B, Fig. 1. The



Method of Determining Recedence and Pressure of Deep Wells

same process of operation will give accurate results with reference to the head under which the pump is working. The friction head without the use of such a device could only be guessed at.

Obviously, all readings must be taken immediately after shutting off the air supply at C or D, otherwise erroneous readings might result, due to a change in temperature of the air confined in the tubes, or slight leakage.

According to the "Electrical World," the main prime mover in the generating station at Independence, Kan., is a double-acting twin-cylinder Strait gas engine, and at one time when this machine was needed to help carry the load an exhaust valve began to give trouble. Shutting off the gas and ignition from the cylinder affected, the men on duty opened the valve chest, took out the defective valve, and replaced it in less than three hours without stopping the engine. The greatest difficulty experienced came from exhaust gases that were discharged up through the manifold from other cylinders. This trouble was overcome by placing a small motor-driven forge blower in such a position that its blast drove these foul gases away from the workmen's faces.

Large Surface Condenser for Commonwealth Edison Co.

The accompanying drawings show the largest Wheeler surface condenser so far built, which is to be installed in connection with a 35,000-kw. turbo-generator at the Northwest Station of the Commonwealth Edison Co., of Chicago.

Looking first at the end elevation, the circulating water entering the station by the inlet tunnel shown at the bottom of the drawing is picked up by the 3½x4½-ft. rectangular suction pipe of the circulating pump. This pipe is in the form of a gooseneck, the top of which is between 11 and 12 ft. above the pump center. The pump is below the water level, but is protected from flooding by this siphon and no valve is needed. A priming pipe shown connects the pump with the water in the riser of the siphon when the small valve is opened, and this enables the pump to pick up its suction and draw the main volume of water over the siphon.

The circulating pump is of the tri-rotor high-speed design for direct-connected drive at 1500 r.p.m. The turbine is a specially designed unit built by the General Electric Co., arranged for driving the circulating pump from one end of the shaft and the air pump from the other, as shown in Fig. 4.

The delivery of the circulating pump is connected through an expansion joint with the water intake of the condenser, and under normal conditions 50,000 gal. of water per minute flows in two passes through the condenser, leaving at the upper left-hand segment in the end elevation, Fig. 1, through a circular discharge main to the outflow tunnel.

Steam is exhausted from the main turbine through a passage about 12x14 ft. in area. The contour of this passage is shown in the plan, Fig. 3.

Upon entering the condenser, the steam first impinges

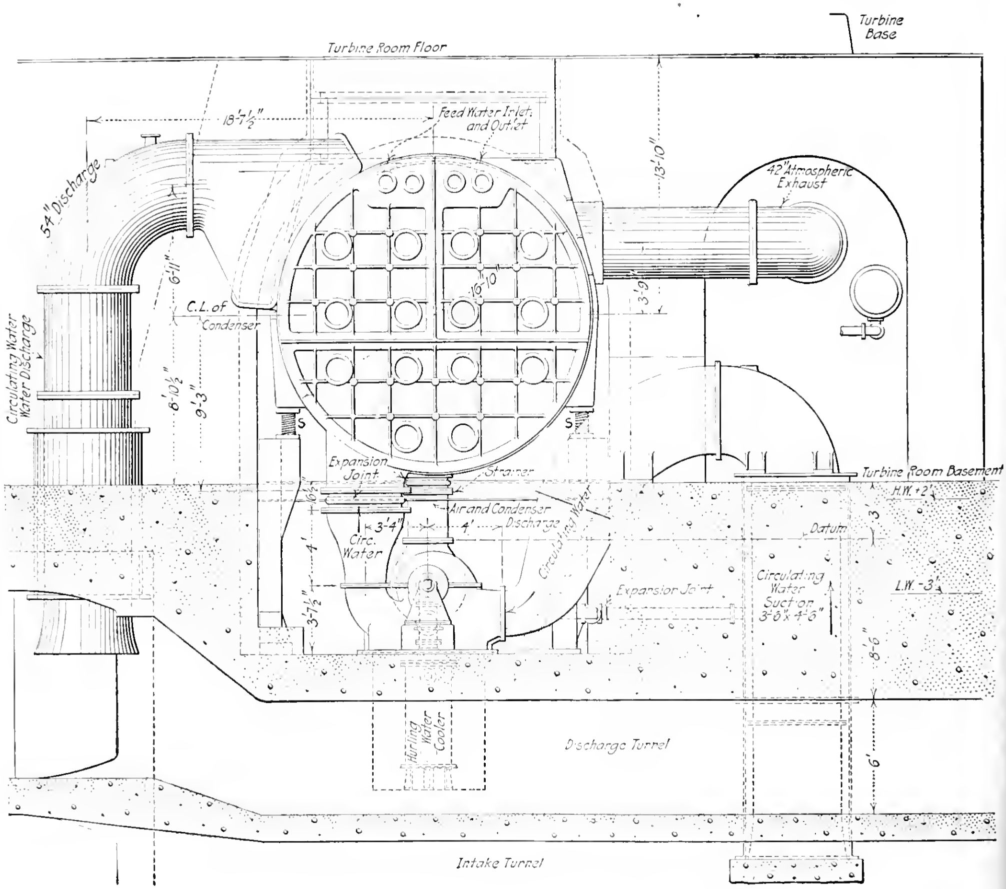


FIG. 1. END ELEVATION OF LARGE WHEELER SURFACE CONDENSER

upon feed-heating tubes arranged at the top of the shell as shown at *AAA* in Fig. 7, through which the condensate is pumped before going to the boiler plant. After giving up part of its heat to these tubes, the steam flows into the condensing space proper, which is arranged with extra wide tube spacing and with the tubes disposed in lines parallel to the flow of the steam. A steam belt extends well below the center of the shell, thus admitting steam well down into the sides of the condenser, all of these features combining to give free flow of steam into and among the tubes. The air is drawn off in the center at the bottom of the condenser through a large outlet pipe, which also carries off the condensate. Baffles *CC* at the sides prevent the short-circuiting of the steam to the outlet.

compression channels; and these plugs, by the momentum due to their high velocity, force the entrapped air before them into the discharge passage against the pressure of the atmosphere. The hurling water enters at *E*, Fig. 5, and is discharged with the air at *C*. In Fig. 2 the combined air and condensate pump is shown at *A*, the hurling water entering at *E* and discharging at *C*, into the well below, the air separating off, the water passing through the cooler alongside, on its way back to the pump. The condensate flows by gravity to the other impeller of the pump at the left in Fig. 5, and is discharged through the pipe *F*, through the heater tubes at the top of the condenser and then to the boiler plant.

The combined Wheeler condensate and turbo air pump

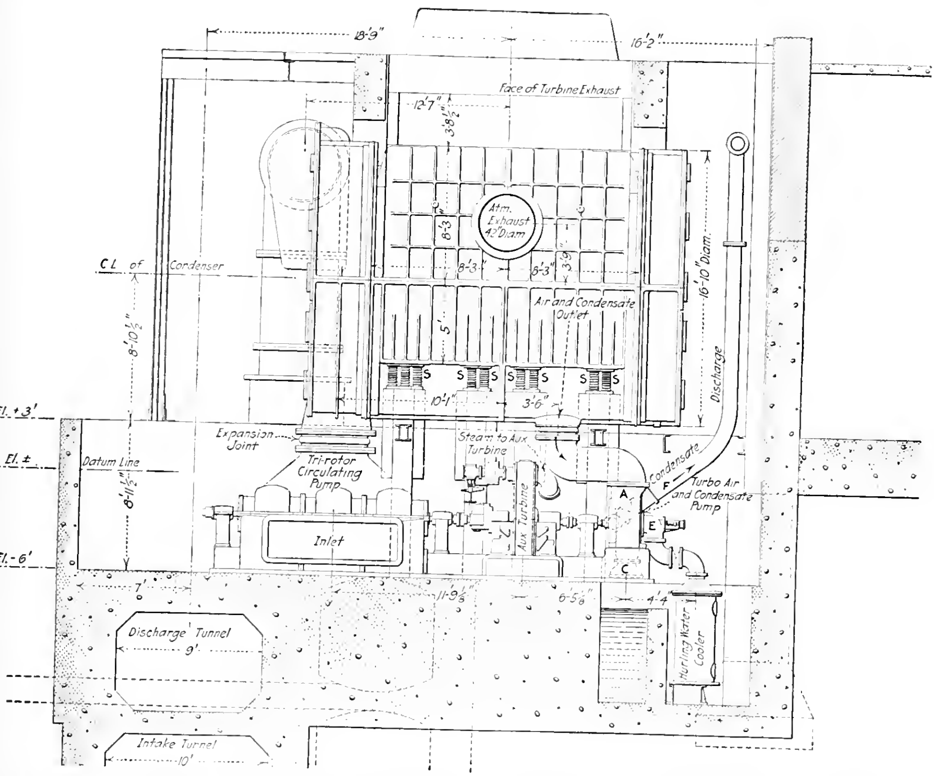


Fig. 2. Longitudinal Elevation of the 50,000-Sq.Ft. Condenser for the Commonwealth Edison Co.

This arrangement of a single outlet for the condensed steam and for the noncondensible vapors is unusual in large condensing units, but was possible in this instance because of the design of air pump which was employed. A section of the pump is shown in Fig. 5. The air and water enter the pump by a common pipe, but are handled separately within the casing. As the condensate enters the chamber *A*, the air turns off from it to the compartment *B*, and is forced out into the chamber *C* by a turbo-air pump impeller shown at *DD*. The action of this pump is shown in Fig. 6. The impeller discharges at high velocity streams of water which are cut into plugs by the sharp edges of the separations of the

is driven by the same auxiliary turbine which drives the tri-rotor circulating pump. Thus the condenser auxiliaries are very much simplified, require less floor space and piping, and less attendance.

In order to allow the condenser free play under varying conditions of vacuum, temperature, etc., its weight is carried upon 18 heavy railroad-type springs, as indicated in Figs. 1 and 2, at *SSS*, the springs resting upon heavy concrete pillars. The shell of the condenser is made of heavily ribbed cast-iron sections, division being horizontally at the center and vertically at the center, making eight sections in all. The weight of shell, tubes, water boxes, piping and contained water will be approximately

200 tons, but this downward force is counterbalanced by an upward force when the vacuum is 29 in., of nearly 170 tons—the upward pressure of the atmosphere on the projected area of the 12x14-ft. opening.

At its maximum capacity this condenser takes care of 400,000 ÷ 50,000 = 8 lb. of steam per sq.ft. of heating surface per hour, which is "some steam" even if it be allowed that 15 or 20 per cent. of it has been already condensed. Imagine an immense pan, 250 ft. long and 200 ft. wide, full of water, over a fire burning with an intensity which would evaporate from every square foot of the water surface over twice as much water as a boiler does at its rated capacity, and you have an

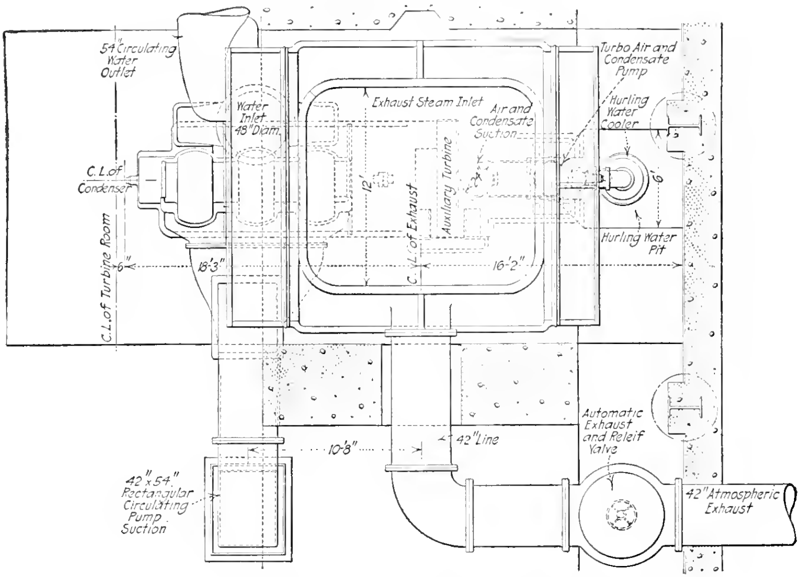


FIG. 3. PLAN OF CONDENSER PIPING AND AUXILIARIES

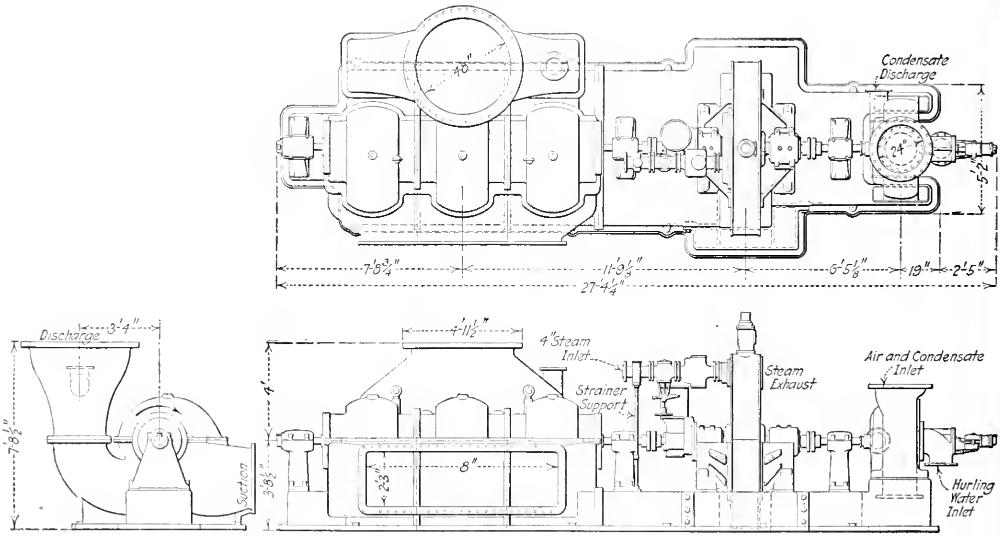


FIG. 4. PLAN, END AND LONGITUDINAL ELEVATION OF TURBINE-DRIVEN PUMPS

There are 50,000 sq.ft. of surface in the condenser, made up of 18 B.w.g. brass tubes. The rated capacity of the condenser is 360,000 lb. of steam with a maximum of 400,000 lb. per hour, and the vacuums to be maintained throughout the year average about 29 in.

idea of the rate of work which this condenser has to undo.

At 75 lb. of condensing water per pound of steam the condenser would require 75 × 400,000 = 30,000,000 lb. of circulating water per hour or over 130 cu.ft. per sec., an amount which with a fall of 10 ft. would develop

$$\frac{30,000,000 \times 10 \times 0.80}{33,000 \times 60} = 121\ hp.$$

and which flowing at the rate of 2 ft. per sec., a rather high rate for a mill race, would make a stream 10 ft. wide and 65 ft. deep. At 29 in. vacuum, or at an average pressure which would support one inch of mercury, the volume of a pound of dry-saturated steam is 654 lb. At its maximum capacity the condenser handles 400,000 lb. per hour or

$$\frac{645 \times 400,000}{3600} = 71,667\ cu.ft.\ per\ sec.$$

which to pass through the 12x14-ft. passage by which the condenser is connected to the turbine would have to have a velocity of 427 ft. per sec. One hundred miles per hour, which is less than 150 ft. per sec., is characterized in the wind tables as an "immense hurricane."

It is true that steam initially at 200-lb. gage, and

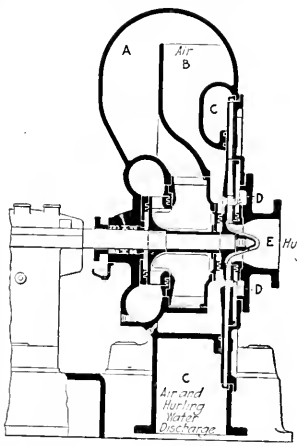


Fig. 5. Combined Condensate and Turbo Air Pump

with 100 deg. of superheat would condense between 20 and 25 per cent. of itself by expanding to 29-in. vacuum, but this is for the academical case of true adiabatic expansion and a 100-per cent. turbine. If the steam rate is 8 lb. per hp.-hr. corresponding to 12 lb. per kw.-hr. and an over all efficiency of 90 per cent. the turbine is converting

$$2546.56 \div 8 = 318\ B.t.u.$$

from each pound of steam into work, 2546.56 being the equivalent in B.t.u. of a horsepower-hour. Steam of 215 lb. absolute pressure superheated 100 deg. contains 1259 B.t.u. per lb. If 318 of these were converted to work there would be

$$1259 - 318 = 941$$

left. The heat of the liquid at 29 in. vacuum, or 1-in. pressure is about 47 B.t.u., which leaves

$$941 - 47 = 894$$

for latent heat. As the latent heat of dry-saturated steam of this pressure is 1047 the quality would be

$$897 \div 1047 = 85\ per\ cent.;$$

that is, for the actual case there would be something like 15 per cent. of the steam already condensed when it came to the condenser instead of the twenty-odd per cent. of the perfect turbine, even including the effect of the heat lost by radiation. It is expected that the condenser will be installed and in operation during the coming summer.

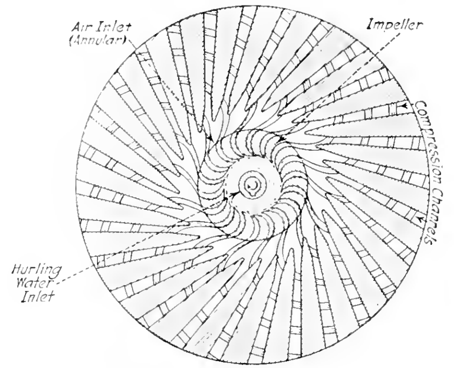


Fig. 6. Showing Action of Turbo Air Pump

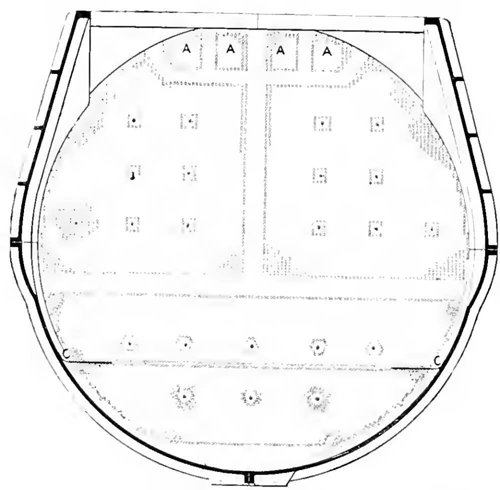


Fig. 7. Showing Arrangement of Tubes and Steam Passages

For the above information and use of engravings we are indebted to Sargent & Lundy, of Chicago, consulting engineers to the Commonwealth Edison Co., and the Wheeler Condenser & Engineering Co., Carteret, N. J., manufacturers of the apparatus.

⁂

How Germans Have Crippled French Industry—Dr. Schrodter claims, in a recent issue of "Stahl und Eisen," that although the French territory occupied by the Germans is less than 4 per cent. of the total area of France, it contains 24.8 per cent. of the steam boilers in number, and 43 per cent. in capacity, for 11 of the principal industries the boilers used by which have been shown in recent official reports.

Synchronous Motor in Low-Pressure Turbine Plant

A POWER contributor has written, asking if there was not something unusual in the manner of controlling the synchronous motor mentioned in the article, "Performance of Low-Pressure Plant," in our Dec. 1, 1914, issue. There is not. However, as many readers may be interested to know how a synchronous motor is controlled when driven by a low-pressure turbo-generator and belted to the same jackshaft as the engines which supply steam to the turbine, the following, from the Jenckes Spinning Co., of Pawtucket, R. I., owners of the plant, will be of interest:

"The synchronous motor is belted to the main jackshaft, which is driven by the reciprocating engines. It also runs in parallel with the low-pressure turbo-generator. The turbine is really of the mixed-pressure type, and when first installed the main or high-pressure valve was left open to be operated by the governor. Much difficulty was experienced with the regulation and it occurred to the owners to shut this valve, so that the turbine would never get anything but low-pressure steam. Now, all the governing is done by the governors on the engines. The synchronous motor floats on the line. When the load on the engines falls off and the turbine is not getting enough steam, the load is made up by the synchronous motor being driven as a generator, which, of course, admits more high-pressure steam to the reciprocating engines and more low-pressure steam to the turbine, and the balance is again restored; if the reverse is true, or the turbine is getting more steam than it can use, it drives the synchronous motor which takes more of the load off the reciprocating engine, which cuts down the supply of high-pressure steam and again restores the balance."

Hose-Clamping Tool

A convenient little contrivance for tightening clamping wire about hose, such as is used around the power plant, is made by the Wieder Manufacturing Co., Warren, Ohio. The tool consists of holder and handle and a slotted pin in which a lever is fitted, Fig. 1. This pin fits in a hole in the main part of the implement, which has a slotted projection at the end for receiving the binding wire.

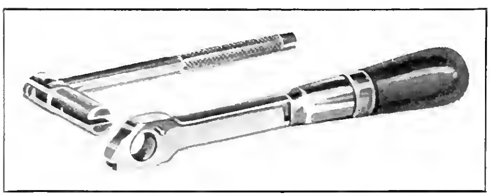


FIG. 1. HOSE-CLAMPING TOOL

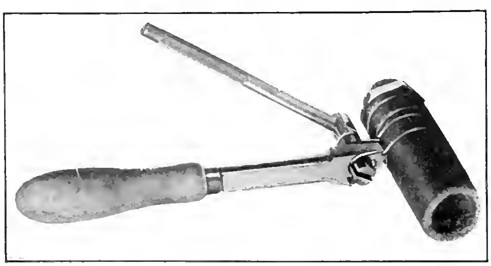


FIG. 2. TIGHTENING THE BINDING WIRE

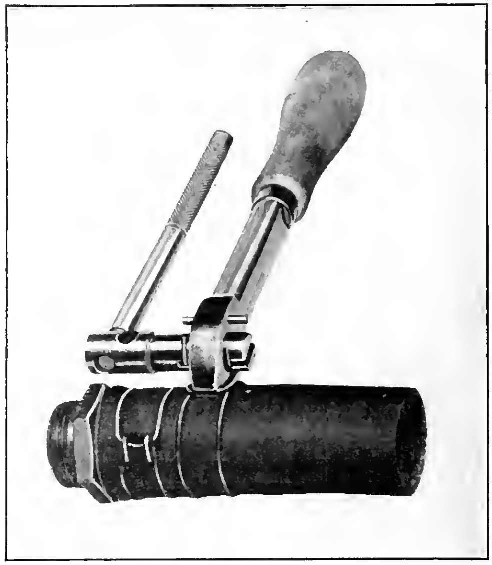


FIG. 3. READY TO TIGHTEN BINDING WIRE

The application is simple. The wire is placed in the slotted end of the tool and bent around, the ends coming about even. The device is then placed against the hose and the loose end wound around the hose and passed through the loop in the wire and the slot in the tightener stud, as shown in Fig. 3. Then it is only necessary to push the lever in the direction to tighten the binding wire, and when tight bring the lever over to bind the loose ends over the end, forming the loop, Fig. 2.

Remarks of the Secretary of Commerce—In passing on the case of an employee who complained that he was required to do work beneath his position in the Department of Commerce, Secretary Redfield said:

You may understand it as my views generally in matters of this kind that I do not know what the kind of work can be which is beneath any man's position. I think there is no work of which I know or have heard that it is beneath my dignity to do, and I am glad to say that I have done the plainest and hardest and, what is sometimes mistakenly called, the most menial work, and am ready to do it again if there is occasion for it. There is no man in the department that ought not be willing to do any kind of decent and honorable work whenever circumstances require it of him, and I know of no work with either hands or head which is not both respectable and honorable if done with the right spirit.

The "Storstad" and the "Empress of Ireland"—The action of the Canadian Pacific Railway Co. against the former owners of the Norwegian collier "Storstad" for the ramming and sinking of the liner "Empress of Ireland" in the St. Lawrence is before the Admiralty Court, Montreal. Originally the claim was for £400,000, but this has now been increased to £600,000, the additional £200,000 being, it is understood, to cover actions for damages by loss of life, either on the part of the relatives of the crew under the Workmen's Compensation Act or otherwise. The "Storstad" was sold for £35,000, which was paid into court, and this amount will be available for, and distributed among, all those who substantiate their claims to it. The Mersey Commission fixed the onus of the blame on Chief Officer Tuftness, of the "Storstad."—Exchange.

Editorials

Another Tribute to Engineers and Firemen

One of the chief lessons thus far taught the world by the European war is the importance of speed in naval activities. More than ever before in history, a difference of a very few knots in the ability of a war vessel to cover a course is counting in the final outcome of conflicts on the sea. Nothing less than speed enabled the now famous "Emden" to pursue her career; speed permitted the "Dresden" to escape so long after the battle off the Falkland Islands; and it was this quality again that so prolonged the destructive mission of the "Karlsruhe." Lack of speed prevented the old-style battleship "Canopus" from joining Sir Christopher Cradock in time to avert the disaster off Coronel, and it was speed primarily that enabled Admiral Sturdee's squadron to crush that of Von Spee immediately after reaching the Falklands.

The value of being able to make twenty-eight knots per hour instead of twenty-four has been demonstrated by the battle cruisers of both Germany and Great Britain in the stirring encounters of the North Sea this winter, and it needs no naval expert to put into words the bearing high speed is likely to have any day upon events of supreme historic interest on the ocean. Only a look beneath the surface is necessary to disclose the importance of faithful performance of duty on the part of the power-plant staff afloat, and it is no discredit to the navigating officers or to the men behind the guns to raise one's hat for a moment in honor of the brave fellows of engine room and stokehole on both sides of the combat whose devotion to throttle and shovel, valve and slice bar, amid fearful and unseen perils, is powerfully helping to decide the issues in the greatest struggle known to history.

Relations of the Consulting and the Operating Engineer

A large part of the work of a consulting engineer consists of analyzing conditions in isolated plants, testing their equipment, and advising their owners what to do to improve the service. Often he is called on the advice of the operating man; more often he is not. To have another step in and tell you how to conduct your own business, especially if he is retained without or against your advice, provokes resentment. But this attitude is becoming less general. Often, the man who protests most about the intrusion of the specialist (in our case the consulting engineer) feels that exposure of his weaknesses is imminent, and of course fights against it.

Consulting engineering, like other professions, has its quacks and fakers. But this kind of man soon gets a reputation that does not help him to do more business or to hold the approbation of his fellow engineers. The work of the consulting engineer brings him in contact with a variety of conditions and things which, together with his technical training, give him opportunities to gain experience that the operating man cannot hope to acquire. It is mainly this difference of training which distinguishes one from the other. If it were possible for operating men to receive such training, there would be need of but few consulting engineers.

The chief cause for the ill feeling that so many operating men have for consulting engineers is not merely because one operates and the other advises and plans. Most power-plant engineers appreciate the professional services of consulting engineers, but are too often suspicious of their presence because of petty things experienced or heard about. For example, a consulting engineer may advise that the present engineer be displaced to make room for a friend of his own. Sometimes, this course is necessary in order that the work which has been done, or is to be done, may be properly carried on.

A man who has been placed in his position by a consulting engineer sometimes feels that his employer is having unnecessary work done on the advice of the consulting man, or that the latter is charging an exorbitant price for his services for certain jobs. He is under obligation to the consulting engineer who got him his job, and rather than incur the displeasure of his benefactor by informing his employer of his suspicions, he drugs his conscience with the conclusion that the employer has money enough to stand it and, after all, no real harm has been done. These cases, we hope, are rare.

It is difficult for most operating engineers to judge of the equity of a charge for consulting work; also, without full knowledge of the work planned, it is not always easy to decide that unnecessary work is being done. The engineer who feels that such conditions exist in his plant should acquaint his consulting engineer with his opinions and thus satisfy himself whether he is right or wrong. Otherwise, a decision arrived at by snap judgment might cause him to lose not only his friend but his job.

A consulting engineer should not make a big ado about reducing the labor force in a plant when the good to follow will soon be offset by losses due to neglect because of a shortage of labor. Little mistakes of this sort sometimes lead to long disputes with labor unions and involve more than a commensurate amount of worry, time and money. Then again, it must be acknowledged that in some plants a reduction of the labor force is justified and often proves a benefit to those laid off, because in new positions they can develop their usefulness to a greater extent than would be possible in positions where time killing was the chief occupation.

Operating men sometimes accuse consulting engineers of playing into the hands of a central station. It is difficult to believe that these alleged acts are numerous enough to warrant as much attention as they receive in some quarters. Usually, when a reputable consulting engineer makes such recommendations, he does so because the condition of the plant, the owner's financial circumstances, and the power consumption all warrant the use of purchased power.

When a plant has been allowed to deteriorate through years of neglect, as some have, and chiefly because those in charge did not sufficiently understand their business, the blame for what eventually happens to it is, first, the owner's, for hiring such poor service, and, second, the engineer's, for not knowing enough of the art of his calling to take care of his own interests.

Granting that consulting engineers are sometimes guilty of malpractice, that some of them stoop to deeds unbecoming a professional man, the conclusion is reached, unwillingly, perhaps, that a great deal of the operating engineer's troubles exist because he does not realize that running a power plant today means more than it did in a past well within the memory of us all. This condition should not exist, for there are many channels open to all for cheaply acquiring the knowledge demanded in modern power-plant practice.

Evils of Low Bidding

In spite of all that has been said and written against these evils, slipshod methods in estimating and underbidding are as common as ever. Nearly every failure can be directly traced to careless bidding and a total disregard of overhead and suitable profit.

Bidding on heating work still seems to be based on so much per square foot of heating surface, and on plumbing, so much per fixture installed. Such methods should never be used except as a check upon a properly made estimate, yet curiously enough, an ever increasing number are still willing to try to make a living by these guesswork methods.

To succeed, every business, great or small, must be operated with a clear conception of overhead expense, or calling it by a better name, the cost of conducting business. This will vary slightly from year to year according to the volume of business done, and should be carefully obtained in percentage upon the cost of the volume done over a given period. Past performance will usually serve as a guide, to be used conservatively in ensuing operations.

Before any article is sold or any work entered upon, the complete cost to the bidder should be known as nearly as possible. First, one should find out just what material is required and its cost, then add the percentage of overhead. The labor required to do the job is the hardest item to estimate accurately; it is usually hard to get away from the allowance of so many hours for fitter and helper per fixture, and if cost cards have been properly kept of previous work, this method is often adopted. It would seem better to analyze each stage of the work and figure on the mean speed of the men, and then check the result by the method mentioned, remembering always that it is safer to over-estimate this item than to under-estimate it. To the labor estimate should be added, as before, the percentage for overhead. The continued difference in bids for the same job and the increasing number of failures show the persistence of careless bidding.

Such ruinous competition works to the moral detriment of the trade as well, inasmuch as the successful low bidder, to come out whole if possible, is tempted to resort to questionable methods in trying to beat the specifications. This reflects on him by the constant disputes, the length of time necessary to collect the final payment, and the knowledge that he will not have a chance to get a repeat order from that customer. Really successful bidders are known better by the number of their old or constant clients, whose good will is the best advertisement possible.

A little missionary work on the part of the technical societies might do something to correct these unfortunate conditions.

The Merit of Individual Effort

The ability to do work above the ordinary is not acquired without special concentration and endeavor. This is what may be called individuality. This characteristic must be developed with several attendant factors if the results are to be what the ambitious worker desires. The expert craftsman of any kind needs that individuality, for he uses his brain as well as his hands. For several reasons this attribute is often highly developed in the man who operates or works in the smaller plant.

There is an abundance of commonplace workers and their position has become precarious, for they are in danger of losing their individuality and power to rise higher than their fellowmen. The man who operates a plant of medium size need not fear being eclipsed by the man who operates the big plant, for in the latter, individuality may be smothered in the volume of work. All depends upon the man himself; he must prove his ability for higher-grade work. If his plant is small and his workers few, he has the greater opportunity to show his individuality. Where resourcefulness and work of the higher grade are sought, one looks to the expert rather than to the utility man.

The man operating a moderate-sized plant is better able to realize his ideals. His operating costs are low, he has only a small force, and his overhead expenses are small. Given these conditions, if his service deserves it, there are not the usual obstacles to his getting sufficient remuneration to more than pay for his seeming limited place in the industrial world. He can give such attention to details that his work will be a source of satisfaction and pride. It should be understood that he must hire only such men as will become an inherent part of his individual operation. This makes the genius, the man who has striven to rise above the ordinary work, an eager worker, and one who can in this way develop his latent powers to excel those who are in the ruts of contentment.

With a limited number of machines and a power that can be supplied at low cost, the operator of the small plant has an opportunity to compel attention. Let him specialize. There never has been a greater demand than exists today for the specially expert. To gain recognition calls for courage, concentration, labor and stability. The man who shows these qualities, no matter how humble his position, is bound to rise.

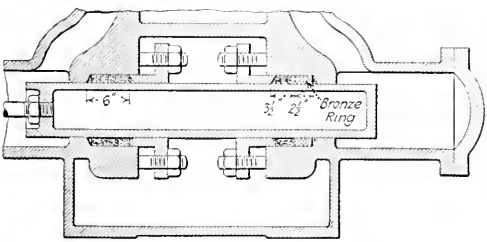
It is greatly to be regretted that Congress failed to approve the two hydro-electric power bills before adjournment. This failure, of course, means that another year of inactivity must pass before anything can be accomplished. Meanwhile the mills are not grinding with the water that is passing.

Correspondence

Depth of Stuffing-Box

The illustration represents the packing-boxes on an outside-packed pump, which was not satisfactory on account of leakage. This pump works on 150 lb. steam and a vacuum of 25 to 26 in. When the packing is tight enough to stop the leak the pump will labor and tremble as if under a very high pressure. Is this due to the deep packing-boxes? Each stuffing-box is 6 in. deep, and the 12 in. of packing, when tight enough to prevent leaking, causes a great deal of friction besides the pressure and vacuum duty.

My suggestion is to replace 2½ in. of the packing-box with a bronze ring made to fit the stuffing-box and



Proposed Bushing for Stuffing-Box

the plunger closely, but not tight enough to cause friction, and to fill the other 3½ in. with three rings of soft square flax packing, thus reducing the total amount of packing from 12 to 7 in. I believe this will permit us to tighten the packing and stop the leaking and still allow the plungers to work freely. I have reduced the number of rings on other pumps from four to two and found that they work better with less power. The packing lasts just as long, and the lining lasts longer than when four rings were used.

Charles E. Sherman.

Manasquan, N. J.

Priming a Centrifugal Pump

The article in the Mar. 2 issue, page 294, on "Priming a Centrifugal Pump," by J. F. Jones, is interesting. Many would like to know more of the details of this unique installation, accident, and repair. In the first place, will Mr. Jones tell how far above the lower water level the pump was and how high the water had to be elevated to reach the irrigating flume? I suppose the dimension of the pump (30 in.) refers to the diameter of the suction and discharge pipes; and this and the capacity (25,000 gal. per min.) stamp the machine as belonging to the class of large pumps. Will Mr. Jones also tell whether he had any trouble with the side thrust from the unbalanced condition implied by the use of one feed pipe? The principle of priming this pump, though a rather large one, should apply to smaller pumps, with which we have all had our troubles.

I have seen centrifugal pumps which were said to work without priming over a suction rise of 6 to 8 ft. These were only 5- or 6-in. pumps, delivering 1000 or 2000 gal. per min. to a discharge rise of 5 or 10 ft. In my experience I have almost invariably had to prime centrifugal pumps, and my experience covers several, from small ones to 10- and 12-in. pumps throwing 4000 gal. per min. to a height of 50 ft.

The tricks of priming were many. One of the easiest was to let enough water from a storage tank flow back to cover the blades of the pump, and then start, when almost invariably, it would pick up the load at once. There was a check valve below the pump, which, of course, made matters much easier than the conditions described by Mr. Jones. He certainly used his wits in sealing the discharge end with the revolving impeller beating the water that remained in the discharge pipe, and then catching the pump with enough vacuum from the steam ejector to raise the water from the intake below the pump. It would be interesting to know the maximum lift for which this method of starting a pump with steam ejector would apply, and still more so to know just how high this particular pump did work, for it is true, in my experience, that such tricks as this of Mr. Jones' are comparatively easy with small pumps, but become increasingly difficult with increasing size of the pump.

The matter of the collapse of the discharge pipe, built to stand 150 lb. internal pressure and failing under less than 15 lb. external pressure, is also interesting, and I hope that experienced pipe men will favor us with some good common-sense explanation.

Charles S. Palmer.

Newtonville, Mass.

Analyzing the Plant's Condition

The report on the condition of the plant under the care of J. C. Hawkins, in the Feb. 16 issue, is interesting and instructive. It also tends to develop enthusiasm, and this alone helps more than anything else to maintain high efficiency in the plant.

The questions in the "New Years Letter" (Jan. 19 issue) cover nearly everything, but a few more might be asked:

1. Is the coal-storage pit moisture-proof? If it is not, much time and labor are lost from too much moisture in the coal.

2. Is the distance between the storage pit and the furnace as short as possible? If not, there is a further loss in time and labor, also wear and tear on extra machinery.

3. Is the percentage of the redeemed waste heat, that is, the heat in the chimney gases and in the exhaust steam, high or low?

4. Have we all the tools necessary for emergencies? If we have, the length of shutdowns will be minimized.

5. Are we using the right grades of cylinder and machine oils?

6. Is all the lubricating oil handled without waste—the proper quantity in the right place at the proper time?

7. Are the suction heads on the boiler-feed pumps right to allow the pumps to operate economically? And are all the pumps operated at the speed conducive to a low percentage of slip?

8. Is the friction horsepower of the plant as small as possible?

SAMUEL L. ROBINSON.

Providence, R. I.

Blocking Up the Governor

It is to be hoped that none of the readers of POWER who operate engines will blindly follow the reasoning in the letter under the above title on page 317 of the Mar. 9 issue, without proving for himself what the effect might be under the various conditions that could arise in the operation of the plant. It will probably not add to the store of knowledge of the average engineer to tell him that the governing of a single engine in a plant where two or more are operating, could be dispensed with provided the load on the plant were always to be more than the maximum capacity of the ungoverned engine and the transmission means between the engine and the load could be depended on to be always in order.

The writer is not an operating engineer and does not want to pose as having superior knowledge in regard to power-plant operation, but unless street-railway power-plant practice has changed remarkably in the past fifteen years, it would seem foolish to say that anyone could guarantee a fixed load for any specified interval during the period of peak loads, when the circuit-breakers are apt to be most active. About fifteen years ago I had some experience in street-railway operation as an engineer, and at peak-load periods had to block the governors on some of the engines to prevent them from dropping. I was an uneasy individual until the load decreased sufficiently to allow the governor-blocking devices to be removed.

If any engineer is forced to operate under similar conditions, even for a limited time, I would advise him to be just as uneasy. If a governor on an engine should become deranged through the breaking of a belt or from any other cause, he should quickly stop it until repairs are made.

There is no class of power plants, as far as the experience of the writer goes, where the load is so likely to be changed from maximum conditions to no load at all, as in street-railway power plants, and if any reader intends to operate such a plant with the governors blocked, as a steady practice, it might be well to block the circuit-breakers, so that they also would be inoperative.

While it is a criticism based purely on snap judgment, the method of applying steam below the dashpot piston of the average governor equipment would not seem to be practical. In the first place, one would expect that when this device operated, the engine room would be showered with oil from the dashpot, and also, that if the piston were as loose fitting or had the area of holes through it usually required to make the operation of the dashpot satisfactory, a 3/8-in. pipe could hardly be expected to furnish a sufficient volume of steam to insure the raising of the governor weights.

However, as stated above, this criticism is not based on actual experience with the device, but since the force of gravity can be had in unlimited quantity and is sometimes used as a pilot to cause the operation of the device as described, it would simplify the apparatus to omit the steam connection and allow gravity to do all the work through a suitable arrangement of levers.

J. E. TERMAN.

New York City.

Uniflow or Una-Flow

Referring to the editorial on page 201 of POWER, Feb. 9, 1915, I should like to add to the discussion the results of a little research on my part.

If you will turn to your Latin dictionary, "Andrews' Latin-English Lexicon," for instance, you will find: "*Una*" (adverb) = in one and the *same* place, or at the *same* time. This seems to be the only form of *unus* which has a distinct sense of *same*. It seems to me that this would make the spelling "una" more nearly equivalent to the German "*gleich*."

The hyphen in una-flow seems to me essential in view of the fact that the use of an adverb would imply that the word "flow" had the strength of a verb.

If the above does not entirely supply the "more subtle" or logical reason for calling the engine by the name "una-flow," which Mr. Alexander finds lacking, we at least are willing to take the additional trouble which the unusual way of spelling entails in view of its advertising value as a unique (unaque) form.

CHARLES C. TRUMP,
Stumpf Una-Flow Engine Co.

Syracuse, N. Y.

Grouting under Heavy Machinery

Some erecting engineers use iron chips or filings and ammonia water, instead of cement or sulphur, for grouting under machinery.

This grout does not set like cement and its action is different. After the ammonia water evaporates, the filings rust quickly and combine into a mass that is about as difficult to chip as cast iron. The engine or other machine is held up on wedges until the filings are hard, and the wedges may then be removed and the holes filled in with the same material.

S. F. WILSON.

New York City.

Referring to the article on this subject by D. N. McClinton, on page 310, in the issue of Mar. 2, he states that it is a matter of considerable discussion whether the leveling wedges should be left under the machinery permanently. From a number of years' experience in erecting engines, I would strongly advise never to leave them in; furthermore, they should be taken out before the grouting has set hard.

A method that I practiced with good results during the last few years of construction work, was to set the bedplate on four wooden blocks a trifle higher than the position desired and close to the anchor bolts nearest to the balancing point of the two ends of the bedplate. Then these bolts were pulled down until the proper height and level were obtained; the wooden blocks would squeeze enough for this. Then the tension on the bolts was removed and the grout was poured in. I found that one part cement and two of sand made the hardest and most lasting grout. When the cement is hard the wooden blocks will give enough so as not to interfere with the proper tightening of the machine to the foundation, but iron wedges will not. Balancing the bedplate at the two heaviest points eliminates much of the danger of springing.

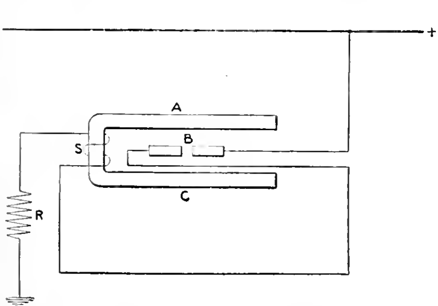
One of my early experiences in the erecting field was replacing a broken shaft of a vertical-engine generating set that had been installed less than two years. The old shaft was removed and no apparent cause for its breaking was discovered at that time. The new shaft was put in place and the engine reassembled. When about to replace the outboard-bearing pedestal it was noticed that the engine and shaft were low. As new bearings were put in with the shaft, it was at first thought that the upper shells were not of the same thickness. These, however, lined up all right. The engine was then raised from the bedplate and it was found that the outboard-bearing end was $^{29}/_{64}$ in. higher than the engine bed. When the bedplate was raised and the old grouting removed, an iron wedge was found driven tight under the part on which the outboard-bearing pedestal was set. No other wedges were found, showing that an inexperienced erector in leveling the outfit had used the generator end of the shaft for a leveling point and had driven the wedge under the small end, springing it up until the shaft showed level. It was surprising that the shaft ran so long without breaking. This incident occurred about eleven years ago, and the shaft then put in is still doing duty.

L. M. Johnson.

Emsworth, Penn.

Modern Lightning Arresters

I have read with interest, "Modern Lightning Arresters," by Charles C. Raitt, in the Dec. 22 issue. The article gives an excellent review of the subject, together with cuts of modern types of arresters, but I would like to call attention to an error in Fig. 11, which is a diagrammatic sketch of a magnetic blowout type of arrester for direct-current circuits.



Magnetic Blowout Type of Arrester (Fig. 11)

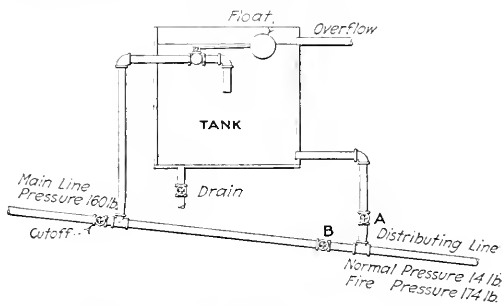
The sketch as published shows the lightning-arrester discharge path passing through gap *B*, through coil *S*, and to ground through the resistance *R*. One of the fundamental principles of lightning-arrester design is to eliminate inductance from the discharge path, consequently the magnetic blowout-type arresters as actually designed do not have the coil *S* in series with the discharge path, but are arranged so that this coil is in shunt with the whole or part of the resistance *R*. In other words, the discharge path from the line is through the gap *B* and resistance *R* to ground. After the abnormal potential has broken down the gap *B*, the direct dynamic current follows and the field is built up by the coil *S* which blows the arc *B* from its normal path and extinguishes it by virtue of its elongation.

V. E. Goodwin.

Pittsfield, Mass.

Leaky Valves in a Water System

In a certain mining camp receiving its gravity water-supply under a 400-ft. head, the valves of the hydrants, about 200 in all, were cut by grit in the water after a few weeks' service. A tank was placed at a point about 30 ft. above the highest hydrant. The water was allowed to flow into the tank under the control of a float-operated valve and thence into the distributing system, as shown in the illustration.



Tank and Float to Control Pressure

High pressure for fire protection was provided for by closing valve *A* and opening *B*.

H. M. Howell.

Los Angeles, Calif.

Good Treatment, Good Service

The human, man-to-man treatment of firemen is being successfully applied at the Mechanical Rubber Co., Cleveland. In short, the firemen at this plant, in the words of the operating engineer, George Lowe, "cannot be driven from their jobs."

The plant contains three hand-fired and three stoker-fired boilers, ranging from 220 to 420 hp. The men are paid a bonus on the CO_2—20c. bonus per 10-hour shift for 9 per cent., 30c. for 10 per cent., 40c. for 11 per cent., 60c. for 12 per cent., and 75c. for 13 per cent. The last figure is frequently reached.

The men have been provided with arm chairs in the firing room and a shower bath near-by. "I believe we are successful with our firemen," says the chief engineer, "because we treat them as men and place them on their own responsibility. There is no question of driving them. They work as if they had an actual financial interest in the success of the plant, as indeed they have."

This attitude toward the firing force is only a reflection of a general spirit of progressive efficiency throughout this plant. In the past year or so, by the application of the system mentioned and its resultant increase in efficiency, by installation of other stokers under the three stokered boilers, which enables them to burn coal at $1.85 instead of at $2.10 per ton, and by the installation of a suction ash conveyor eliminating five ash wheelers at $2.50 per day, this power plant has saved over $18,000 per year net.

E. W. Waldron.

New York City.

Tank Vents

The vapor pipes from return tanks, blowoff tanks and open heaters should each extend separately through the roof; otherwise, blowing down the boilers may cause a back pressure on the other tanks. Where separate lines are impractical, check valves on each line joining the vent from the blowoff tank will prevent back pressure, but they will cause a slight resistance, due to the weight of the check. Such check valves should be so located that no condensate can accumulate above them, because it will tend to hold the valve closed and may at some time freeze.

All outlets such as those from feed-water heaters should empty into a funnel in order to make noticeable any excessive waste of water to the sewer.

T. W. Reynolds.

Mt. Vernon, N. Y.

Trip for High-Voltage Switches

Referring to the description of a "New Series Trip for High-Voltage Oil Switches" in the Mar. 2 issue, I would say that we have such a switch installed on a 60,000-volt circuit.

We found that the wooden rod running from the relay to the trip coil on the operating lever was of such small material that it buckled under action and made the switch late in opening, so that the switches on the low-tension side of the transformers opened first.

This was remedied by putting an ordinary tube insulator half way up the rod, thus preventing it from buckling in the center.

J. B. Crane.

Duluth, Minn.

Paints for Engineering Purposes

In your issue of Feb. 16 appears an article by E. W. Percy, entitled "Paint for Engineering Purposes." To some of the assertions made in this article I believe anyone with a technical knowledge of paint and painting would feel impelled to make objection.

I find myself at variance with Mr. Percy's statement that pure white lead and boiled linseed oil are unequaled for purposes of protection. As a matter of fact, I am sure that there are many combinations that are better. Even for white work many believe that white lead is improved for protective purposes by the addition of other pigments. Be that as it may for white paint, there are at least half a dozen colored pigments that protect better, last longer, and cost less than any white paint.

The usual substitute for white lead is not zinc, but barytes. The zinc is used to give a good color and, when lead is also used, to improve the wear of the latter. Whether it does this or not is a subject of controversy, but I am convinced that it does.

Red lead is not "cheaper than" white lead, but much dearer, because it covers less surface, pound for pound. It does protect steel excellently—but "there are others."

Mr. Percy is sadly "off" in his varnish technology. Varnishes are usually made with fossil gums (resins and not rosins) that were once tree gums, as Mr. Percy states, but which probably have not been in contact with a tree since man appeared on the earth.

Amyl acetate is the orthodox solvent for pyroxylin. I quote from Worden a typical lacquer formula:

	Lacquer, Ounces	Thinner, Ounces
Pyroxylin	5.5	
Amyl acetate	45	40
Refined fusel oil	7	6
Wood alcohol, 97 per cent	24	35
Benzine, 62 deg	32	20
Benzine, 71 deg	20	27

"Metallic Paints," by long established usage, are certain iron-oxide paints made either by grinding native hematite ores or, indirectly, by roasting certain native ores until the iron content is completely dehydrated and converted into ferric oxide. They are red or brown in color. The type of paints to which Mr. Percy refers are known in the trade as bronzes.

The copper paint used on ships' bottoms is usually the oxide or finely divided metallic copper (copper scale).

G. B. Heckel.

Philadelphia, Penn.

More about Graphite

In a plant in Pittsburgh we have five vertical water-tube boilers, each rated at 310 hp., working 24 hr. a day at 25 per cent. over rating. After the use of graphite for some two months we found it necessary to open these boilers about once a week and inspect them by running a light through each tube, as the scale was coming off in such quantities and in such large pieces that it was liable to block some of the tubes and interfere with the circulation. After using graphite four months, our boilers were clean and free from scale. Before using it we were compelled to clean them completely every six months and the front bank of tubes every 30 days. This was expensive, as shown by the following figures. When we were cleaning the boilers with an air-driven turbine it cost about $1300 a year, besides having them out of service from 30 to 60 days each year. Since we have used graphite it has cost us about $475 a year, and we have the use of the boilers continuously.

When we started to use graphite we fed 3 lb. per 100 hp. per day of 24 hr., and after the boilers were clean we cut down the amount to 1½ lb. per 100 hp. per day of 24 hr. Every time we wash out a boiler, which is every 30 days, we put 3 lb. of graphite in the rear steam drum.

John L. Armstrong.

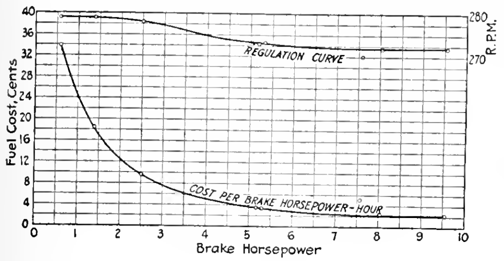
Pittsburgh, Penn.

Correction

Mr. Wentworth's discussion of "Oil Engine Tendencies" in the Mar. 16 issue, page 383, contains the statement: "I have demonstrated that for a running engine 150 lb. is sufficient to ignite the fuel, the hot plate being needed only for starting in the engine which I have developed." The latter part of this sentence should have read: "The writer has developed a type of engine not limited in size and which needs *no* hot plate."—Editor.

A Gasoline-Engine Test

The accompanying curves show the results of a brake test on a 10-hp. gasoline engine, made to determine the cost per brake horsepower per hour under different loads and, incidentally, the regulation under these loads. The gasoline pump was disconnected and the gasoline was fed to the vaporizer by gravity from a 5-gal. can provided with a nipple and cock; the flow being regulated so that only a small amount appeared at the overflow. This was



Regulation and Cost Curves

collected and poured back into the supply can, which was weighed at the beginning and at the end of each run. The revolutions per minute were taken almost continuously by speed indicators and the average readings were used in the calculations. Each run was of 30 min. duration, which, although not long enough to obtain extremely accurate results, was sufficiently accurate for the purpose. The cost is based on gasoline at 15c. per gallon.

R. S. Hawley.

Golden, Colo.

Lignite in Deep Furnace

A plant owner purchased two 72-in. by 20-ft. high-pressure tubular boilers to be erected in the West. One of them was to be equipped with shaking grates, the other with a special grate and furnace using forced draft through a sealed ashpit and also through a hollow bridge-wall. This type of furnace had been successfully installed in other plants using Wyoming lignite, the coal to be used in the new plant. The advantage claimed for the special furnace was the admission of enough air through the fuel bed to burn it to CO, which, rising above the bed, mixed with the warm air entering through the hollow bridge-wall and burned to CO_2.

In arranging the details of the plate-steel boiler fronts, the contractor's representative noted that the special furnace required a height of 54 in. from grate to boiler. This required the boiler to be set much higher than usual; so to make the fire-doors of all boilers the same distance from the floor, he raised the second boiler so that the furnace height was also 54 in.

Test runs on both boilers were conducted and the boiler with the special furnace showed an evaporation of 5.2 lb. of water per pound of coal, and the efficiency was, roughly, 67 per cent. The other boiler, equipped with shaking grates, under like conditions, gave but 2.5 lb. of water per pound of coal, the efficiency being approximately 33⅓ per cent. The result was so much lower than that attained in the old plant, where plain grates were used and the boiler walls badly cracked, that the owners entered an emphatic protest.

Since the type of shaking grate was a good one, the stack capacity ample and the setting air-tight, it was conceded that the trouble lay in the extreme depth of the furnace. Luckily, the steel front was so sectionalized that the fire-door could be raised along with the grates so that the furnace depth would be made 26 in. instead of 54.

This was done and on a second test an evaporation of 4.15 lb. of water per pound of coal was obtained. This value is good for shaking grates using lignite that slacks badly and that causes an appreciable loss of fuel into the ashpit. Perhaps the cause was that the lignite gave a short flame and the great depth of the furnace allowed too much air to come in contact with the burning gases.

L. H. Morrison.

Dallas, Tex.

[If the setting was air-tight above the grate the additional height of the furnace should have given good instead of poor furnace efficiency.—Editor.]

Diagonal Joints

The efficiency of a diagonal seam is a matter of angles and should be calculated for each different angle. J. E. Terman, March 2 issue, p. 296, compares the strength of a diagonal joint in a testing machine to a longitudinal joint of a cylinder. To take another view of it, let us compare the diagonal with a girth seam. That there is an additional strain in a diagonal joint in a boiler not exerted in a testing machine is pointed out by Mr. Terman. There is a generally accepted statement that the force tending to rupture a cylinder girthwise is one-half as great as that tending to rupture it longitudinally. This is equivalent to stating that the effective efficiency of a girth seam is twice as great as that of a longitudinal seam of like design. This can easily be shown mathematically, and the relation is so apparent that tests are not necessary to prove it. The relative strength of a diagonal seam compared to either a girth or longitudinal joint can be calculated, but under test conditions do not apparently come up to expectations.

As an illustration, consider a single-riveted diagonal seam to hold a patch. Suppose the single-riveted seam has an efficiency by test of 50 per cent. of the solid plate. It will then have an efficiency of 50 per cent. as a longitudinal seam and a comparative efficiency of 100 per cent. as a girth seam. A diagonal seam of the same proportion will have an effective efficiency somewhere between these two values, decreasing as it swings from the girth seam. If a section of the diagonal joint were tested it would probably fail at less than 50 per cent. The inclination is to jump at the conclusion that the diagonal seam is weaker than the longitudinal and that the calculations on the strength of diagonal joints are in error. A little further consideration of the matter shows that the test of the straight joint showed 50 per cent. and no more, yet with this joint in another position it will be, relatively, twice as strong.

If, then, we compare the strength of the diagonal seam to a girth seam instead of to a longitudinal seam, as has been the practice, we will approach nearer to the calculated efficiency for a diagonal joint. The test efficiency will show higher than calculated, and the error will increase as the diagonal joint deviates from the girth joint. This comes about because in the machine there is a pull in one direction, while in a diagonal boiler joint there is an endwise and longitudinal pull combined, and until a testing machine is made that will pull in the two directions at right angles to each other, the result of tests along a diagonal line will not give very accurate results.

THOMAS GRIMES.

Houghs Neck, Mass.

In calculating the strength of a diagonal seam it is necessary to take into consideration the well known fact that internal pressure exerts twice the strain on the longitudinal seam or section of the sheet as on the girth seam or sheet section. In Fig. 1, AB represents a longitudinal seam, CD a circumferential seam, and EF a diagonal seam. Since the strain on a longitudinal seam AB is twice that on a girth seam CD, it is evident that

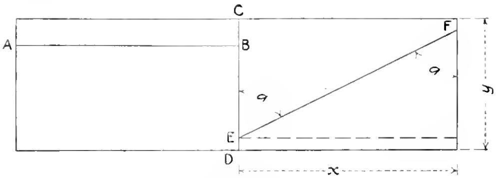


FIG. 1.

FIG. 1. RELATIVE POSITION OF SEAMS

the smaller the angle a, the greater the internal pressure a given diagonal seam will withstand.

Now, the force acting on a unit of length on a diagonal seam EF is the component of the girthwise and longitudinal stresses. In the three types of seams suggested, with the plate, size and pitch of rivets the same, the efficiency of the seams will be identical, but the internal pressure they will withstand will depend on the direction of the seam with reference to the axis of the cylinder.

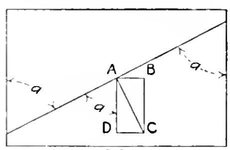


FIG. 2.

FIG. 2. CALCULATION OF EFFICIENCY OF DIAGONAL SEAM

P = the bursting pressure of the cylinder through the solid sheet and if E = the efficiency of the joint, the bursting pressure through the joint AB, Fig. 2, will be PE.

From this is derived the formula

$$AC = \frac{PE}{\frac{1}{2} P \sqrt{1 - 3 \sin^2 a}} = \frac{E}{\frac{1}{2} \sqrt{1 - 3 \sin^2 a}}$$

effective efficiency of diagonal seam, and from it a table of constants may be calculated.

The effective efficiency of the diagonal seam may be determined from the formula

$$EE = \frac{E}{\frac{1}{2} \sqrt{1 + 3 \sin^2 a}}$$

where

EE = Effective efficiency of diagonal seam;

E = Efficiency of joint calculated as a longitudinal seam;

a = Angle made by girth seam and diagonal seam.

With a table calculated from the formula, and by its use E and a being known, it is only necessary to divide E by the required factor to determine the effective efficiency of the diagonal seam; or, the efficiency of the longitudinal seam being known, to lay out a diagonal seam of equivalent efficiency at a given angle, multiply the efficiency of longitudinal seam by the factor corresponding to the given angle. The product will be the efficiency of the joint at that angle. In repair work we can calculate the efficiency of the longitudinal seam, assuming the highest efficiency E practical for the seam in the patch. Dividing the first into the second will give the greatest angle at which the effective efficiency will equal the longitudinal efficiency.

R. D. IRVINGTON.

Boston, Mass.

Piping Bubblers to Avoid Waste

Of all inefficient things, a bubbler drinking fountain seems the most wasteful. When, as boys, we used to lie down at the edge of a brook to drink, we did not think of the brook as flowing for that express purpose, but when we open a bubbler valve the flow is solely for the sake of getting a drink, and we consume about one per cent. of what flows and waste the rest.

We think of the installation of a drinking fountain as a plumber's job. A plumber will tell you at once that any waste pipe must go into the sewer. The water that has gone by one of these bubblers is just as good to feed the boilers, flush the closets, or for any mechanical purpose as it ever was.

The waste pipe can be made to discharge into an open tank or into the return tank of a vacuum heating system and thus improve the vacuum because the water is cold. There should be an effective check valve in the line so that hot water cannot back up into the bubbler. This is especially necessary if the drain pipe surrounds the feed pipe for a short distance. I know of a case where the water in the bowl which had backed up heated the supply pipe enough to scald a man by the first rush of water. It is better to discharge into a separate tank from which the water can be pumped wherever desired, and in that way prevent waste.

E. F. HENRY.

Worcester, Mass.

Vacuum Helps in Making Repairs

With high steam pressure and superheat there is likely to be more or less trouble when making repairs, on account of leaking stop valves on the sections of headers which have been cut out.

In some plants it is the practice to cross-connect the suctions of the dry-vacuum pumps. A convenient use can be made of this connection when making pipe repairs. If the section of the header cut out has a connection to an engine or turbine, the throttle can be opened wide, the inlet valves blocked open, the connection to the condenser opened, and the dry-vacuum pump will then draw the leaking steam past the point of repair.

Of course, the proper way would be to replace the valves, but this cannot always be done. However, with the bolts out of a flanged joint and the steam burning the hands, the foregoing stunt will be found worth while.

JOHN F. HURST.

Louisville, Ky.

Inquiries of General Interest

Crushing Strength of Boiler Plate—In computing the strength of a boiler joint what is understood by the crushing strength of the plate?

J. R.

The crushing strength of the plate is its ability to resist distortion from the compressive stress which is incident to drawing the sheet against one side of a rivet in exerting shearing stress in the rivet.

Safety of Cracked Mud Drum—Would it be safe to continue the use of a cracked mud drum of a water-tube boiler after drilling and plugging the ends of the cracks?

F. S.

The drilling and plugging might reduce the tendency of the cracks to extend in length, but could not otherwise increase the safety of the drum, which may not have sufficient strength for safety even if the cracks do not extend

Relative Heat Value of CO_2 and of CO—What are the relative heat values derivable from carbon in fuel burned to CO_2 and to CO?

G. B.

When carbon is burned completely to CO_2 there will be given off 14,500 B.t.u. for every pound of carbon burned, but when CO is formed there are 4400 B.t.u. given off per pound of carbon burned, or less than one-third as much heat.

Relative Lengths of Pump Cylinders—Why is the water cylinder of a steam pump made longer than the steam cylinder?

J. W. D.

So that there may be latitude in length of the piston rod without the water piston overrunning or leaving too little clearance in the ends of the water cylinder for the greatest possible stroke of the steam piston in either direction.

Boiler Foaming from Temporary Use of Good Feed Water—How is it explained that the temporary use of a good quality of feed water causes a boiler to foam?

G. N.

Where a boiler is coated with scale a pure feed water will sometimes dissolve the scale, leaving the metal bare in spots which transfer heat much faster than parts that are covered with scale, and the violent boiling over places where there is little or no scale is likely to result in foaming or priming.

Circulating Pipe for Blowoff—How can a circulating pipe be connected to the blowoff pipe of a return-tubular boiler?

R. C.

A circulating pipe of a size smaller than that of the blowoff pipe can be connected from a point in the blowoff, outside of the rear wall and on the boiler side of the blowoff valve, to a point in the rear head of the boiler a short distance below the water line. The circulating pipe should be provided with a stop valve, which should be closed whenever the boiler is blown off, but at all other times should be left wide open.

Per Cent. of Fuel Saved by Heating Feed Water—What is the formula for calculating the per cent. of fuel saving from the use of a feed-water heater?

A. S.

For practical purposes the heat saved in raising the temperature of feed water may be regarded as directly in proportion to the rise in temperature. The steam pressure and feed-water temperatures before and after heating being known, the fuel saving can be computed by the formula,

$$\text{Fuel saving in per cent.} = \frac{100\,(t - t_1)}{H + 32 - t_1}$$

in which

t = Temperature F. of feed water after heating;
t_1 = Temperature F. of feed water before heating;
H = Total B.t.u. above 32 deg. F. per pound of steam at the boiler pressure (to be obtained from tables of properties of steam)

Maintaining Air Supply in Air Chamber—How can a supply of air be maintained in the pump air chamber of a high-pressure service pump?

J. G.

An automatic air pump for supplying the air chamber may be provided by connecting a vertical 2-in. or 2½-in pipe about 30 in. long, with a stop valve at its lower end, to one head of the water cylinder and providing the upper end of the pipe with a tee and 1¼-in. check valve opening inward and a ¾-in. check valve opening outward and connected to the pump air chamber. For operation of the air pump it is necessary that the pump to which it is attached shall be in operation. To start the air pump, first open the valve connected with the water cylinder to charge the air pump with water; then partly close the valve until the check valves begin to work.

Compression of Steam in Duplex Pump—How is compression of exhaust accomplished in the steam end of a duplex pump?

W. L.

Separate steam and exhaust passages are provided in each end of each steam cylinder, the cylinder ports of the steam passages being located in the extreme ends of the cylinders or nearer the ends than the cylinder ports of the exhaust passages. The exhaust ports are placed so near together that before completing the stroke from one end of the cylinder the piston covers the exhaust port at the other end of the cylinder. When the exhaust passage is thus closed, any exhaust steam then remaining in the cylinder and steam passage on the exhaust side of the piston is compressed by it during the remainder of the stroke.

Computation of Indicator Diagrams—An 8x10-in. engine having a 2-in. diameter piston rod runs at 200 r.p.m. The indicator diagram from each end of the cylinder has an area of 2.5 sq.in. and a length of 4 in., and the scale of spring is 50 lb. per sq.in. What is the i.hp.?

S. H. E.

In each diagram the mean effective pressure would be

$$\frac{\text{area}}{\text{length}} \times \text{scale of spring, or } \frac{2.5}{4} \times 50 = 31.25 \text{ lb. m.e.p.}$$

The area of the 8-in. diameter piston being 50.265 sq.in. and the cross-section area of the 2-in. diameter piston rod being 3.1416 sq.in., then for 10-in. stroke and 200 r.p.m., there would be

$$\frac{31.25 \times [50.265 + (50.265 - 3.1416)] \times \frac{10}{12} \times 200}{33{,}000} = 15.37 \text{ i.hp.}$$

Application of the Prismoidal Formula—What would be the cubical content of a piece of timber 16 ft. long, 6x6 in. at one end and 4x8 in. at the other?

T. E. H.

Assuming that the ends are parallel planes, as, for instance, both square with one of the edges of the timber, then the content can be found by the prismoidal formula

$$\text{Volume} = L \times \frac{A + a + 4M}{6}$$

in which

L = Length;
A = Area of one of the parallel ends;
a = Area of the other parallel end;
M = Area of cross-section midway and parallel to the parallel ends.

The ends being, respectively, 6x6 and 4x8, the parallel mid-section would be 5x7, and the length being 16 ft., then the volume would be

$$(16 \times 12) \times \frac{(6 \times 6) + (4 \times 8) + 4\,(5 \times 7)}{6} = 6656 \text{ cu.in.}$$

or

$$\frac{6656}{1728} = 3.85 \text{ cu.ft.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Future Methods of Utilizing Coal*

SYNOPSIS—Economic pressure due to increased demand and cost of coal will force improved methods of combustion and the recovery of the various byproducts contained. The relative costs of fuel and capital are the determining factors. There is no need for conservation as ordinarily understood. Future generations, with their fuller knowledge and wider vision, will be better able to take care of themselves.

There is at the present day a certain amount of coal buried in the earth's crust. Coal is being slowly formed at some points on the surface of the earth, but the rate of formation is so low in comparison with the rate of consumption that for all practical purposes the supply available for human consumption may be assumed to be that already formed. If this view is taken, it is evident that the amount of coal which can be used by man in the future is definitely limited; when he has used up the coal now in the earth's crust, or that part of it which he can extract, there will be no more available for use.

The estimates of the length of time which will elapse before this condition is attained vary greatly, but most of them allow humanity at least a few hundred years before the exhaustion of all available coal. Opinions as to what may happen when the time of ultimate exhaustion arrives are equally variable. Some believe that humanity must perish because of the enforced cessation of industries and because of the impossibility of keeping warm during the cold seasons of the year. Others believe that by that time hydro-electric development will have been carried to such a point that electrical energy will entirely take the place of heat derived from coal. Still others are satisfied to let the future take care of itself and to assume that the human brain is going to be able to continue to devise methods of changing the environment to suit the needs of the human animal.

I am inclined to take the last view myself, as I believe that the centuries of human history which are available show that each successive generation has become better able to force its dictates upon nature rather than to be subservient to the unrestricted action of natural forces. In other words, subsequent generations will be better able to care for themselves than the present generation and there is no need to waste good time and effort in trying to solve their problems for them with a smaller stock of knowledge and a narrower vision.

In taking this viewpoint it is not necessary to hold ourselves responsible to future generations for the use we make of the coal stores which we are depleting at such a rapid rate. We may consider ourselves free to use this material as our industrial development requires, though we are, in a certain sense, morally bound to make that usage as economical as possible on the basis of the general principle that it is not good economics to waste wealth of any sort.

If, then, we attempt to look into the future for the purpose of predicting the methods which will be in use for the utilization of coal, we must not warp our vision by an erroneous assumption of the necessity of conserving the supply. We must rather study industrial developments of the past and after discovering their general trend, attempt to apply this knowledge to the particular field under discussion.

It has been characteristic of nearly all industries that they started in a small way under conditions which did not require the most economical production. Thus the shoe industry was started by numerous individuals scattered over the country, who purchased leather, nails, thread and other raw materials in small quantities and then worked them up into shoes on individual orders received from people living in the immediate neighborhood. The modern packing industry sprang from the small butcher who slaughtered for local consumption and disposed of the hides and other byproducts in the easiest way possible. The clothing industry was originally confined to the home, the land or the live stock producing the raw material, which was worked up by the family of the owner into the clothing required by that family.

All of these industries have grown until they are scarcely recognizable as the offspring of their forebears. This has been brought about by organization, which is merely the combination of capital and the division of labor for the purpose of producing the biggest possible yield from given raw materials or natural supplies.

In the shoe industry scientific development produced the marvelous machines which are now used in producing leather and shoes and the railroads which later transport the factory-made product to the scattered consumers.

In the packing industry the refrigerator car made possible the concentration of the slaughtering industries and, coupled with mechanical and chemical invention, assisted in building up large modern plants.

Spinning and weaving machines, cutting, sewing and pressing machines, coupled with the railroads, have made possible the huge centralized clothing industries of the present day.

The study of the packing business tends to throw considerable light upon the probable future development of the coal industry. It is not so many years ago that, in this country at least, meat on the hoof was so plentiful that it could be slaughtered in most expensive ways and still be sold at a profit at such a low figure as to bring it within the reach of practically all families. Conditions are now different and meat on the hoof is comparatively scarce. It therefore brings comparatively high prices and if all or practically all of the purchase price, transportation and slaughtering expenses had to be borne by the meat and hide, the prices of these commodities would be so high as to put them beyond the reach of many families even in this comparatively opulent country.

But the modern packing house manages to sell every part of the animal for some purpose. Some parts, such as those sold in the form of dressed meat, are disposed of after little modification, while others, such as horns, hoofs and fat, pass through elaborate manufacturing processes before they are ready for the market. When it is remembered that every one of the numerous products is sold on the average at such a price as to bear its share of the cost of the animal, of its transportation, and its slaughter and dressing, it is evident that the principal product, meat, can be sold at a lower price than would otherwise be possible. Moreover, waste has been reduced to a minimum; all parts of the animal which cannot be used for food are used for other purposes.

The coal industry, particularly in this country, is in much the same position today as would be a packing house which produced meat only. Coal is removed from the mine, put in marketable condition with the minimum possible expenditure and shipped to the consumer. The greater part of it is burned under boilers just as it is received or after breaking to smaller sizes.

As the supply in sight in the ground decreases, as mines become deeper and as freight rates increase, coal becomes more and more expensive. This process must continue so long as the methods at present in vogue in the industry continue and the cost of coal must ultimately become a serious burden on industries in which the coal charge forms a large fraction of the total charge. In view of what has happened in other industries it is but natural to assume that when economic pressure makes it necessary, the coal industry or the methods of utilizing coal will be so modified as to obtain the maximum possible number of products with the maximum possible economic value from each ton mined, provided such products are obtainable.

We are accustomed to think of coal as merely so many stored or latent units of heat energy purchasable at so much per thousand or million. It is far better, however, to view it as a collection of chemical substances and combinations which are capable of almost an infinite number of transformations and recombinations to form innumerable new end products. If coal were merely a collection of units of heat energy the cost per unit would of necessity continue to increase until it reached a prohibitively high value. Taking the view just suggested, however, it is possible that chemical jugglery of the constituents may be made to develop substances marketable at such prices as to materially reduce the necessary selling price of units of heat energy.

The principal constituents of coal are carbon, hydrogen, oxygen, nitrogen and sulphur, and these are the blocks out of which innumerable organic and inorganic chemical compounds are built. Just how these various constituents will be liberated or recombined for the purpose of increasing the economic value of a ton of coal in order that the selling price of units of heat energy may be kept down to a reasonable figure, must be more or less a matter of speculation. It is, however, pertinent to note that processes of this kind are already in use in some of the European countries and particularly in Germany, and it is reasonable to suppose that

*Abstract of paper read by Prof. C. F. Hirshfeld before the Detroit Engineering Society, Mar. 23, 1915.

future development will follow along some such lines as those already partially developed. An investigation of these methods may therefore assist in arriving at a more correct prediction of future methods.

In general, development is carried on along three lines: First, the thermal efficiency of heat engines and plants is brought to the highest possible figure in order to reduce to a minimum the number of heat units which must be purchased by anyone concerned in the generation of power; second, byproduct fuels of various varieties are made from the raw coal, or from the coal in the process of utilization and some of these may have such desirable properties as to be worth more per unit of heat energy than is the raw product. Their use or sale therefore tends to reduce the price paid for heat units in the raw coal. Third, many byproducts useful in numerous arts are made and their economic value helps to reduce the cost at which units of heat energy or their products must be sold to yield a profit.

It will be observed that when the coal-mining and consuming industries develop in this way, they begin to approach the condition of the modern packing industry. The capital involved is enormously increased; many more kinds of labor are required and the subdivision of labor is carried to a far greater extent; and the economic value of the product per ton of raw coal is enormously increased.

The parallel may be drawn still more closely. Meat for human consumption may be considered the primary product of the packing industry. The selling price is continually increasing, but the rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product. Heat energy may be said to be the primary product of the coal industry and the selling price of this is continually increasing. The rate of advance is kept lower than it otherwise would be by increasing the number of products per unit of raw material, giving a greater economic value to the products per unit and reducing the charges against the primary product.

Development along these lines has thus far progressed along two principal paths. The raw coal is subjected either to a destructive distillation process with the exclusion of air, or to a process of incomplete combustion in the presence of air The former method yields a solid fuel called coke; combustible gases of a more or less permanent nature; condensible vapors of great chemical and fuel value; and other substances, such as ammonia, cyanides, sulphur compounds and others. The latter method yields solid, incombustible refuse or ash of comparatively small value; large quantities of combustible gas of great value; condensible vapors which are becoming of greater chemical importance daily and are also becoming available as fuel; and small quantities of chemical compounds of more or less value.

By such means as these fuel material becomes available in solid, liquid and gaseous forms, and the particular variety best suited to any use may be chosen therefor if price permits. It is, of course, impossible to obtain more heat units than were originally contained in the fuel. There is in reality always a loss in these processes, but the thermal efficiency with which the smaller number of resulting heat units can be used may more than balance the thermal losses occurring during the modification of the fuel. Great developments have been made in the use of gaseous and liquid fuels during the past few years. It is now possible to use such fuels for the generation of steam, for industrial heating, and for the operation of prime movers at efficiencies much higher than seemed possible of attainment a short time ago. Surface combustion and the internal-combustion engine in its various forms are pointing out lines of development leading toward constantly increasing thermal efficiencies.

These statements must not be interpreted as an argument for the immediate adoption of gas firing and of the universal use of the internal-combustion engine. Other matters must be given consideration as well as the cost of fuel. The cost of capital is of equal importance.

At present the costs of capital and of fuel are both increasing, but the cost of the latter is increasing more rapidly than that of money. Even now the cost is such as to warrant greater capital investment for procuring greater thermal efficiency than could have been justified a few decades ago. Ultimately the cost of fuel must rise to such values as to warrant the investment of the necessary capital and the training of the necessary labor to make possible the use of fuel in such ways as to produce the greatest economic production per ton of raw material.

When that time comes it is probable that coke, or something resembling it, will be the principal solid fuel; gases formed during the production of the solid will be used in internal-combustion engines, or by surface combustion, or in ways not yet discovered; and liquid fuels formed during the production of solid fuel will be used in high-efficiency, liquid-fuel engines. Before they are used the liquid and gaseous fuels will be robbed of many valuable constituents, which will be used in producing fertilizers, medicines, paints, dyes, preservatives, waxes, flavoring extracts, commercial chemicals and many other products yet undreamed of.

Summarizing these ideas, it seems probable that:

1. Improved or more economical methods of utilizing coal will not and need not be brought about by any consideration of conservation as ordinarily understood.

2. Such methods will be brought about by cumulative economic pressure due to the natural operation of increased demand for fuel combined with decreased quantities and increased cost of mining and transportation.

3. When such methods are thus forced upon humanity they will follow, in a general way, the course developed in other industries under the force of similar circumstances.

4. These methods will consist of a preliminary treatment of the raw material to produce fuels with different physical and chemical characteristics which will adapt each form to use in particular kinds of apparatus or in particular industries.

5. Coincident with this treatment will be produced numerous non-fuel byproducts of great value in the then existing markets.

6. The spreading of the cost of the raw material over so many products will prevent the excessively rapid rise in the selling price of fuel per heat unit and this, combined with high efficiency methods of utilization made possible by the relative prices of fuel and capital, will yield the same sort of an economic balance as now exists. Humanity will probably then, as now, bemoan the fact that it could not have lived several generations before, when fuel was "cheap," and will probably express great sympathy for the coming generations that will have to face the problems of life with a still more depleted coal supply.

Many will probably object that the cost of modifying coal, as, for instance, by the destructive distillation process, has always been so expensive that little is to be hoped for along such lines in the future. In answer to such criticisms it is only necessary to point out the fact that despite the rising prices of coal, labor and capital, the selling price of gas made by such processes has steadily decreased. It is admitted that further decrease cannot be brought about by exactly the same methods as have been used in the past, but it shows very little faith in the progress of the human race to assume that the present status in any industry represents the ultimate development of which humanity is to prove capable.

Refrigeration Night, Chicago Section, A. S. M. E.

The chief paper presented before the meeting in the Grand Ball Room of the LaSalle Hotel, Mar. 19, was by Heywood Cochrane, Western manager for the Carbondale Machine Co. The subject was "Ice Making as a Byproduct for Central Stations," a digest of which follows:

One point of difference between the electric-light and the ice plant is that of distribution. There is hardly any limit to the extent of the former, but the latter soon reaches a size where the cost of distribution more than offsets the saving. Individual plants of from 80 to 150 tons, located in the best centers of distribution, are preferable to large-capacity plants adjacent to the station.

With condensing water under 70 deg. F. it is possible to use exhaust steam at 3 lb. pressure in the generator of an absorption system. This steam is condensed, furnishing a portion of the distilled water required for making ice. About 55 to 60 lb. of steam per hour per ton of ice is required for this purpose. With condensing water at 90 to 95 deg. it is not possible to run on less than from 20 to 25 lb. exhaust-steam pressure, because of the high condensing pressures necessary. Such pressure would seem prohibitive, yet plants operating under these conditions are proving economical. It is not generally known that, properly designed, the absorption machine is an ideal installation for warm water conditions. Just as it takes little more coal to carry 125 lb. boiler pressure than it does 100 lb. (less than 1 per cent.), it takes comparatively little more steam in the generator to produce an ammonia pressure of 200 lb. than it does 150 lb.

An electrically driven compression plant will require from 43 to 70 kw.-hr. per ton of ice, depending upon its size and local conditions. At 1c. per kw.-hr. the power costs per ton will usually average between 50 and 60c. From the central-station manager's standpoint, in the larger cities, such as Chicago, the privately owned electrically driven plant is the proper combination, while in smaller cities it is much more profitable to own the ice plant direct.

It is possible in a properly designed compression and absorption plant, say of 80 tons' capacity, with a 20-ton machine of the former type and a 60-ton of the latter, to make ice at a lower fuel cost than 35c. In this case there should be two 40-ton tanks, the compression machine being used on one-half the coils of one tank and the absorption machine on the rest. The steam from the compressor and auxiliaries would furnish the 3600 lb. of exhaust required for the generator of the absorption machine. Making all raw-water ice with coal at $2 per ton, having an evaporative efficiency of only 6 to 1, 6½ tons would be required and the fuel cost would be 16c. per ton of ice. Such an 80-ton plant could be run on a 125-hp. boiler, and with a second such boiler in reserve, the first cost, interest, depreciation, etc., would be low, so that including labor it should hardly be more than 30c. per ton.

If a neighbor could be found requiring a certain amount of power and heat, a straight 80-ton absorption machine could be installed. By using the expansive force of the 4800 lb. of steam per hour required by the generator, in an economical uniflow engine, current could be sold, not bought, which would further reduce the operating cost.

One drawback about the electrically driven plant is the possibility that public-service commissions at any time may decide that the rates quoted ice plants are too low and order them raised. Rates higher than 1c. per kw.-hr. seem prohibitive, although they are paid in some places. Sometimes the ice-plant manager looks only at the comparatively low operating cost when running full capacity and forgets that service charges add to the cost at other times. The importances of such charges should never be underestimated.

A properly designed combination plant owned by a central station in a Southern city of about 50,000 inhabitants was described.

REFRIGERATION VS. HEATING

Otto Luhr was asked to explain in an elementary way the principles of operation of a refrigerating system. He did this by comparing it to an ordinary steam-heating system, as in reality it is nothing more than a heating system reversed, with the only difference that in a steam-heating system heat is carried into the rooms that are to be heated, whereas in a refrigerating system heat is carried out of the rooms that are to be cooled. In both cases the latent heat capacity of the heat-carrying mediums is of vital importance. In ordinary steam-heating systems there is a boiler and heating coils. The boiler is partly filled with water, and the heat that is created by the combustion of fuel is absorbed by the water, which is changed into steam by the constant addition of heat. This steam is conveyed to the heating coils at comparatively low pressure and temperature, the latter usually being about 212 deg. F. As the room temperature is generally about 70 deg. there is a difference of 142 deg., and heat will constantly flow from the radiators into the surrounding air.

With the refrigerating system the reverse process takes place. The system consists of a heat-carrying medium confined in piping similar to that of the heating system. If the medium could be purchased cheaply no further apparatus would be necessary, but as it is expensive the heat absorbed by it must be abstracted and used over and over just as is the water in a heating system. To do this a heat elevator in the form of an ice machine and a heat extractor in the form of a condenser become necessary. The temperature of the medium is raised either directly by steam or by the application of power in the form of compression. It is necessary to raise the temperature of the medium in either of these two ways so that water or air of ordinary temperature will remove some of the heat contained. Water is generally used, as it is cheaper. It has the same effect on the heat-carrying medium as the room temperature has on the heating system. When it arrives at the condenser the medium is in a gasified state, and by the action of the cooling water, which constantly takes heat away from the gas, it is liquefied. It is then ready to start on the same cycle, which is constantly repeated.

Mr. Luhr explained how the liquid ammonia in the coils was vaporized by absorbing heat from the room to be cooled, and enumerated some of the qualifications which go to make up a good refrigerating medium.

As to the different systems, each was well adapted for specific cases. For instance, it is not good policy to use a CO_2 machine when the cooling water is scarce or high in temperature. On the other hand an ammonia-compression machine would not be desirable when there was plenty of exhaust steam and an abundance of low-temperature cooling water, especially when low temperatures were to be carried in the cooling system.

The principles of operation of refrigeration systems can best be understood by keeping a steam engine or a heating system in mind and considering the refrigerating end a reverse process. In a steam engine the efficiency is the greatest the farther apart the inlet and outlet temperatures of the steam. In the compressor it is just the reverse; that is, the closer the two temperatures can be brought together the higher will be the efficiency. For this reason it is necessary to work with a suction pressure as high as possible and with a condenser or discharge pressure as low as possible, as long as the proper refrigerating results can be obtained. This means that the pipe surface in the refrigerating room must be large, so that the difference in temperature of the medium in the pipe and the air surrounding the pipe can be small.

CO_2 MACHINES

Fred Wittenmeier, vice-president and chief engineer of Kroeschell Brothers Ice Machine Co., explained the action of the CO_2 machine, which is now made in capacities up to 150 tons. Its greatest application is in hotel basements, on board ship and in other places where space is limited and where the escaping fumes from a possible rupture of the pipe lines might cause serious inconvenience.

In the last ten years air cooling by means of the CO_2 system has also made rapid progress. The usual practice is to place direct-expansion coils in the air washer. The properties of CO_2 were briefly given, and the results of tests made on an air-cooling system in a church and on an ordinary refrigerating system on board ship were shown on the screen. The principal object was to show that with condenser water in the eighties good results could be obtained from the CO_2 system, notwithstanding the general belief that it is not adapted for use with high-temperature cooling water. In the test on the air-cooling system, the water went into the condenser at 84 deg. and came out at 106 deg. From the ship log the inlet temperature of the water was 82 deg. and the outlet temperature 88 deg. As far as economy was concerned, under normal conditions the CO_2 system gave results comparable to those obtained from ammonia or SO_2 systems.

FROM THE VIEWPOINT OF THE CENTRAL STATION

E. W. Loyd, of the Commonwealth Edison Co., discussed the topic of the evening from the viewpoint of the central station. In efforts to obtain a load which would improve their load factor, particularly in the summer months, an investigation was made of the ice-making field. Many data were collected and the amount of power required for refrigerating installations determined. This was turned into kilowatt-hours and a price fixed at which the company could sell current. Rapid progress has been made and one third of a million tons of ice is now produced in the City of Chicago by central-station power. This is 10 per cent. of the total made in Chicago, and has been made possible by the recent developments in raw-water ice making. The trend seems to be toward raw-water ice where fairly pure water can be obtained. It was originally estimated that the load factor on an ice plant was about 65 per cent., but according to data collected by the company the annual load factor does not exceed 45 per cent. Exceptions were found, but in any case it was not above 65 per cent. on an annual basis. As to the kilowatt-hours required per ton, there was a wide variation, largely due to the varying efficiencies of the plant and the equipment installed. The company found that the number of cans employed per ton of ice has a bearing on the subject. At the present time they were supplying 7000 hp. for ice making, and the total amount of power required for this purpose in the city was estimated at 70,000 hp. The rate charged was 1c. per kw.-hr. An analysis shows that the distributing cost is low, as the current is delivered in large quantities to one service. The increment of cost to take on this business was a minimum. It increased the summer load and reduced the overhead charges, and it could be shown that the rates were comparable to those for other classes of service.

MULTIPLE-EFFECT COMPRESSION

By means of some simple experiments and lantern slides Gardner T. Voorhees explained the action of his device designed to obtain multiple-effect compression. Low-compression vapor first enters the cylinder, and near the end of the stroke vapor under a higher pressure is admitted. The cylinder thus contains a denser charge and at the same speed does more work, or the same amount of work with less power. The device by which these results were obtained was illustrated and the results of a number of tests given to show the economies obtained. In one particular case, with 90 deg. F. cooling water, 70 per cent. more ice was made for 25 per cent. less power, after the compressor was fitted for multiple-effect compression. Slides of the Quincy Market Cold-Storage

& Warehouse Co.'s (Boston) machine, the largest in the country, were shown. This machine, designed by F. L. Fairbanks, is fitted with a multiple-effect compression device and has given excellent results. For a complete description of this machine see "Power," Dec. 8, 15, 22, 29, 1914, and Jan. 6, 1915.

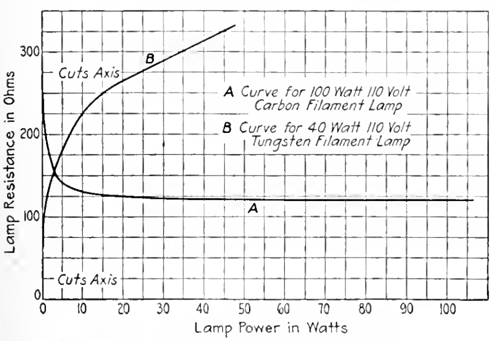
Dimmers for Tungsten Lamps*

By A. E. Waller

The introduction of tungsten lamps has brought about a complete redesign of the apparatus used for lamp dimming in theatrical work. The control rheostats, or dimmers, which were built to regulate the illumination of carbon lamps were found unsatisfactory when the carbons were replaced by the metallic-filament tungsten lamps.

The resistance characteristics of the two types of lamps in actual operating conditions indicate the reason for the difficulty. Tungsten has a positive temperature coefficient of resistance, while carbon has a negative temperature coefficient. For instance, if we have a carbon and a tungsten filament of the same cold resistance, when both are at full incandescence, the tungsten will have 35 times the resistance of the carbon filament.

The curves shown were plotted from tests made on a 40-watt tungsten lamp and on a 100-watt carbon lamp, both giving practically the same candlepower at 110 volts. Curve A, which is for the carbon lamp, has little slope between the 10- and the 100-watt abscissas, an interval which represents the working range of the lamp. Since the lamps must be totally extinguished without opening the circuit,



Lamp Resistance vs. Lamp Power

the dimmer is built with enough resistance to reduce the input below 10 watts, in this case to 6 watts, which is attained at 28 volts.

The calculation of the resistance per step of a dimmer for a carbon lamp is similar to that of a generator field rheostat, or of any other controller operating in series with a substantially constant resistance across a constant-supply voltage. The current of the lamp at the rated 110 volts is 0.9 amp., the minimum to which this will be reduced by the rheostat is 0.18 amp., and the working resistance of the lamp is approximately 122 ohms. At the minimum current the resistance is actually 138 ohms, but it is satisfactory in designing to take the resistance as constant at 122 ohms.

The negative coefficient of the carbon filament produces a slight change of resistance which assists the action of the dimmer. When a resistance step is cut into circuit, the current flowing is reduced, the filament cools and increases in resistance, which causes a further slight decrease in the current. Any part of the rheostat cut out of circuit increases the current, thus raising the filament temperature and allowing a slightly greater current to pass. This action is most pronounced at low voltages, the lamp resistance remaining practically constant over the greater part of the working voltage.

In striking contrast is the tungsten lamp, which opposes every attempt at control, and must be regulated by much finer divisions of resistance to get gradual dimming. The shape of curve B indicates that the tungsten filament changes in resistance throughout the entire working range of the lamp; furthermore, that the rate of change is not constant. The correct resistance for each step is readily obtained by calculating the resistance required in series with the lamp at various voltages. At 110 volts the tungsten lamp takes 0.35 amp., and the minimum is 0.08 amp. at 10 volts. The corresponding resistance change is from 312 to 125 ohms.

A comparison of curves A and B shows the marked contrast between the tungsten and the carbon lamps. The resistance of the tungsten lamp at full incandescence is about 16.5 times its cold resistance, while that of the carbon filament at full incandescence is approximately half the cold resistance. The tungsten filament becomes visible red at 10 volts, the carbon at 28 volts.

*From a paper presented at the midwinter convention of the American Institute of Electrical Engineers, New York, Feb. 17 to 19.

Two Flywheels Explode at Illinois Steel Co.'s Plant

During the morning of Mar. 17, shortly after 3 o'clock, two immense flywheels exploded in the No. 1 rail mill of the Illinois Steel Co. at South Chicago. Out of 150 employees imperiled, one man was killed, two have since died, two more were scalded about the face and arms by escaping steam and a fifth received two scalp wounds. The property damage is estimated at $75,000, and about 300 employees will be thrown out of work until the mill can be rebuilt, which will probably take about six weeks. That more were not killed or injured is a marvel that might be explained by the immediate rush for safety by employees accustomed to danger and consequently alert to the slightest warning.

After a shutdown for the winter, the mill had been reopened about 10 days previous to the accident. It consists of a long building about 80 ft. wide, housing three compound engines and their respective rolls. The dummy engine, which caused the accident, was located at the north end of the mill, the finishing engine 112 ft. south, and 104 ft. farther on the blooming engine. They are all of the tandem-compound type and practically in line. The dummy engine was installed in 1890 and compounded in 1905. It had cylinders 34&60x66 in. and a speed of 80 r.p.m. The flywheel, which was of the solid-rim split type, weighed 65 tons, and its dimensions were about as follows: Diameter, 25 ft.; face, 20 in.; thickness of rim, 20 in. The finishing engine had cylinders 40&70x66 in. and a 70-ton flywheel. The blooming engine was about the same size.

From the blooming rolls the bars of metal are passed along to the roughing rolls driven by the finishing engine, then to the dummy rolls and back to the finishing rolls. At the time of the accident a bar had just been rolled by the dummy engine and passed back to the finishing set of rolls at the center of the mill. While waiting for another bar to be delivered from the roughing rolls, the dummy engine speeded up and the flywheel exploded. The flying pieces from this wheel caused the flywheel on the finishing engine to give way, and between the two 125 ft. of the roof was brought to the floor. A traveling crane having a 77-ft. span, and at the time being located above the dummy engine, was demolished, but in stopping some of the heavy parts helped to save a considerable portion of the roof. Of the few pieces landing outside the building, one passed down into a shed and damaged a number of motor armatures which had been stored there.

The low-pressure cylinder of the dummy engine was demolished, the connecting-rod broken and the bedplate cracked at the bearing. The finishing engine was stripped of its valve gear. A piece of one of the flywheels smashed a valve bonnet on the high-pressure cylinder of the blooming engine and ruptured the steam connection between the two cylinders. A wiper on this engine was instantly killed and a machinist and a helper burned about the face and arms by the escaping steam. More damage at this point was prevented by a roll rack containing nine 30-in. rolls, three high and three wide. Seven were broken. The engineer on the finishing engine was so badly hurt that he died a little later, but the engineer of the dummy engine escaped with a couple of scalp wounds.

Fortunately, the steam piping had been designed for just such a contingency. The main supply pipe had been carried outside the building. The pipe leading to each engine passed through the wall, then down and directly across to the throttle, so that there was no overhead piping to flood the mill with steam in case of a rupture.

The governors were of the standard automatic-cutoff flyball type, driven from a sheave on the main shaft by three independent ropes. In addition, each engine was equipped with a quick stop which might be operated from a number of push buttons placed in convenient locations. There was no automatic stop to set a definite limit on the speed. Such a device in working order, whether electrical or mechanical, would have prevented the accident.

Several years ago an automatic electric stop had been tried out on the blooming and finishing engines, but the graphite, scale and dirt common to steel mills interfered with its operation. The contacts would build up, close the circuit prematurely and frequently stop the engine with a bar in the rolls. It was not stated how often the contacts were inspected, but the result was a discontinuance of the automatic feature. Dependence was placed on the engineer at the throttle and the hand-operated stops previously mentioned.

In his report the engineer of the dummy engine claimed to have pushed one of the buttons, but apparently too late to save his engine. This action, however, would shut off the steam and eliminate one of the sources of danger.

Admission to the scene of the explosion was not granted, so that it is impossible to form accurate conclusions as to the cause of the accident. It was claimed that all the equipment was in good order, as far as known. No flaws were detected in the metal of the flywheels, and the governors had operated satisfactorily during the 10 days since the shutdown.

The following theories are advanced as possibilities. Not infrequently, water finds its way into the pits of the flywheels. Some of it may have been splashed on the ropes driving the governor, causing them to slip and allowing the engine to run away. Breakage of the ropes would produce the same result. Either might happen in the grease- and scale-laden atmosphere of a steel mill, depending upon the frequency and thoroughness of inspection.

Water-Power Motor Drive in a Flour Mill

An extremely flexible arrangement has been worked out by the Northwestern Consolidated Milling Company for one of its large flour mills at Minneapolis. This plant is driven by both a waterwheel set and a large synchronous motor connected to the same shaft. When water is plentiful the turbine wheel is operated at full load, pulling the mill and converting its surplus power into electrical energy in the motor unit, which is for the time operated as an alternating-current generator. The electrical energy thus generated, amounting to several hundred horsepower, is used to supply other mills and elevators operated by the same company.

When, however, the output of the waterwheel is insufficient to pull the mill itself, the synchronous motor is called into service, taking its supply from the mill steam-turbine plant. In case of low water this motor is used to drive the whole mill. On still other occasions, when the mill is shut down and it is desired to utilize the water power, the waterwheel can again be used to drive the motor unit as a generator, feeding its entire output into the mill system. In preparing the switchboard connections for this flexible arrangement it was, of course, necessary to provide for reversing the wattmeter connections by means of a reversing switch when the motor is operating as a generator.—"Electrical World."

Turbines in Warships

Once more the U. S. Dreadnaught "North Dakota" is in drydock for repairs to her turbines. These engines have been in trouble a good part of the time since the big ship was launched in 1910, and the navy's experience in this case has been such an unhappy one that it is unlikely that engines of this kind will be installed in new battleships.

Something like $200,000 has been spent on the "North Dakota" for repairs in five years, nearly half of which has been for repairs to the turbines. Naval experts deny that the frequent troubles with the engines are due to defects in material or construction, but charge the cost wholly to inaptitude.

Curtis turbines were installed in the "North Dakota" as a test for this type of engine and the "Delaware," a sister ship finished and launched in the same year, was equipped with reciprocating engines. On their trial trips the "North Dakota" made her required speed of 21 knots an hour, while the "Delaware" did half a mile better. Navy Department officials say that in coal consumption and efficiency the turbines have not made good, in comparison with other types of engines. At cruising speed, the coal consumption of the "North Dakota" has been from 30 to 40 per cent. greater than that of the "Delaware," even when the turbines were working well and in good repair.

Most of the trouble with the "North Dakota's" engines has been with her blading, and most of the repairs have been in renewing defective blading, nozzles, and the like. When she was sent to the Norfolk yard last month, to again underge repairs, an examination disclosed that most of the blading in the first and second rows of the first stage were broken, having been bent over and twisted out of shape by the steam pressure, almost like so much cardboard. It is now being repaired, and when finished, the ship will again be placed in commission, although it is the opinion of the department steam engineers that eventually the turbines will have to be removed and replaced with either electrically driven machinery or turbine reduction gear.

OBITUARY

W. C. GREEN

W. C. Green, well known to the Western mining trade for the past 25 years, and for the past six years representative of the Mechanical Goods Department of the Diamond Rubber Co., died Feb. 13, from an attack of pneumonia. Mr. Green's work for the Diamond Rubber Co. will be carried on by C. A. Tracy

FREDERICK W. TAYLOR

Frederick Winslow Taylor, distinguished for his labors in the field of increasing industrial efficiency, and the originator of the Taylor system of scientific management, died in Philadelphia, Mar. 21, of a sudden attack of pneumonia.

He was born in Germantown, Penn., in 1856, and received his early schooling in this country and in France and Germany. Impaired eyesight prevented his entering college at the age of 18, and he began an apprenticeship in a Philadelphia pump works. Completing this course, he entered the Midvale Steel Works and shortly afterward was in charge of the toolroom. In six years he was chief engineer of the company. By night study he was enabled to obtain an engineering degree from Stevens Institute in 1883.

While at Midvale he studied systematically the production and its expense, and increased the output 200 to 300 per cent. by increasing the men's pay 25 to 100 per cent. Later, this became his specialty: "The development and application of the science of shop organization and management." From 1890 on he practiced as a consulting engineer along these lines. In 1898, while retained by the Bethlehem Steel Co. to increase its machine-shop output, he with Maunsel White discovered the Taylor-White process of heat treatment, increasing the cutting efficiency of tool steel.

He presented two notable papers to the American Society of Mechanical Engineers: "A Piece-Rate System and Shop Management" and "The Art of Cutting Metals." In 1906 he was president of the society.

PERSONALS

W. D. Ranney has been appointed chief smoke inspector for the City of Columbus, Ohio.

William Siebenmorgan, formerly chief engineer of the C & C Electric & Manufacturing Co., of Garwood, N. J., is no longer connected with that company, his resignation having taken effect early in February.

ENGINEERING AFFAIRS

The American Society of Mechanical Engineers is to hold a meeting in San Francisco on Sept. 16 and 17, in connection with the Panama-Pacific Exposition. For the benefit of those who will attend, a special train schedule will be arranged over the Southern Pacific. It is planned to pick up at New Orleans those members who will start from the Middle West or South and other points farther west than New York. According to the schedule as at present arranged, the party will leave New York either Thursday evening, Sept. 9, or Friday evening, Sept. 10, and will stop at Niagara Falls, the Grand Cañon and possibly Colorado Springs. The Hotel Clift has been selected as the headquarters of the society during the meeting. An International Engineering Congress will be held in San Francisco from Sept. 20 to 25.

POWER

Vol. 41 NEW YORK, APRIL 13, 1915 No. 15

Two Ways of Going to Work

Both are getting the same salary now, but not for long

(Suggested by the letter from Milton W. Elmendorf, Wilkinsburg, Penn., page 515)

Hydro-Electric Power Plant at Chittenden, Vt.

By Thomas Fraher

SYNOPSIS—This hydro-electric development operates under a head of 430 ft. and was built to utilize the storage of a reservoir already provided, the water of which performed no work in flowing to the lower reservoir through East Creek. The plant consists of two 1850-hp. turbines, which drive two 1000-kw. generators. Provision has been made for a third unit.

The hydro-electric plant of the Pittsford Power Co., which is located in the town of Chittenden, about seven miles north of Rutland, Vt., presents an interesting feature in the fact that it operates under a higher head than any similar plant in the East.

The purpose of this development was to utilize the storage of a reservoir already in existence, the waters from which, in flowing along what is known as East Creek to a lower reservoir, performed no useful work. As the lower body of water served a hydro-electric plant of 1200-kw. capacity, erected in 1905 and in active operation, no water could be diverted from this basin, and the logical location of the new station was one as near to the elevation of the lower reservoir as nature would permit, to secure the maximum head, and so placed that all water discharged through the new plant would be available for subsequent use at the existing station already in operation.

The upper reservoir, although several times larger than the lower, is of comparatively small capacity, the quantity of water impounded being about one billion cubic feet. The area of the reservoir is 2414 acres, and that of its watershed about twenty-seven square miles. Notwithstanding the static head of 487 ft., the small amount of water available makes the horsepower development rather limited. The capacity of the two units at present installed is about 3300 hp., but provision has been made for the future addition of another similar unit.

After surveys and examinations of the territory, the location of the Pittsford Power Co. plant was decided upon as shown in Fig. 1, where it is possible to utilize the maximum head with a minimum length of penstock.

A study of the contours of the East Creek valley showed that by keeping the pipe line on the east side a suitable gradient of 0.3 per cent. could be obtained, which would permit a wood-stave penstock being built from the outlet of the reservoir to a point about 2700 ft. east of the proposed power house. At this latter location the drop is abrupt, thus requiring a steel penstock from there to the power house.

From the outlet of the dam of the Chittenden reservoir, a wood-stave penstock, 5-ft. inside diameter, extends 13,400 ft., except a section *A*, where the contours compelled the introduction of a $\frac{5}{16}$-in. steel pipe on an 80-ft. radius curve. At *B* there is a curve of 80-ft. radius, 75 ft. long, formed of three lengths of $\frac{5}{16}$-in. steel pipe, the first of which is a taper section, changing from 60 to 54 in. From *B* to *C* the diameter of the steel pipe is 54 in., and from the latter point to the venturi meter, just outside the power house, it is 52 in. The thickness varies between $\frac{5}{16}$ and $\frac{9}{16}$ in.

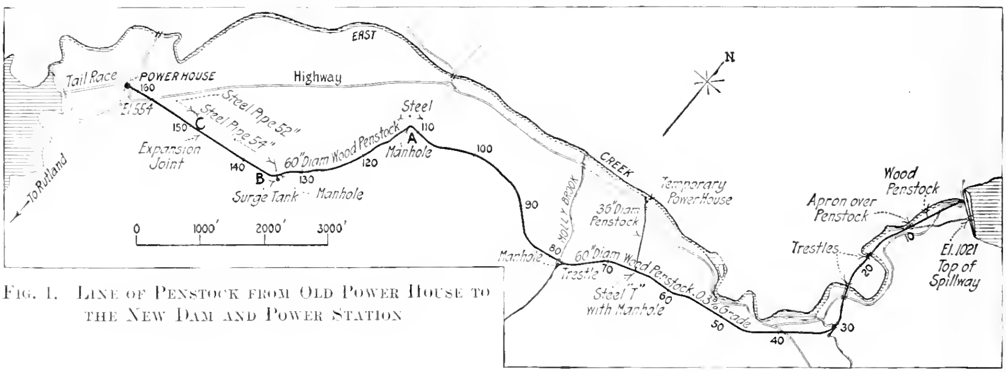


Fig. 1. Line of Penstock from Old Power House to the New Dam and Power Station

The elevation of the water in the Chittenden or upper reservoir, when the flashboards are on the dam, is 1021 ft., and the center of the outlet pipe in the dam is 975 ft., so that, dependent upon the stage of the water in the reservoir, the initial head on the penstock may vary between 46 and 5 ft., which is about as low as it is desirable to operate.

Connection between the outlet valve of the reservoir and the penstock is made through a steel nipple, which has a manhole and a 24-in. nozzle. Upon this nozzle was placed a 24-in. steel pipe, 55 ft. high, to act as a vent to prevent collapse when drawing off the water. This pipe was protected by a double frost casing of wood staves and is heated electrically by an old car heater.

For a distance of about 1400 ft. from the outlet of the dam the penstock was made of spruce cut from the company's tracts near the site of the work. The spruce staves were $2\frac{5}{8}$ in. thick, made from 3x8-in. and 3x6-in. stock and milled so that it took 21 staves from the wide stock and 7 from the narrow to make a section of pipe.

The wood-stave penstock, except the first 1100 ft., is made of live Douglas fir, 2½x6-in. stock, kiln dried, the finished staves being 2⅛ in. thick and 36 pieces being required to make a section of 60 in. diameter.

All bands were ⅝-in. diameter openhearth steel, a complete band consisting of two pieces, one having standard heads at each end and the other having 7-in. rolled threads at each end.

The spacing of the bands varied between 6½ in. at the dam, where the maximum head would be 46 ft., to 3 in. at the end of the wood-stave section, where the maximum head would be 85 ft. Manholes of pressed steel are provided at intervals, as indicated.

1000-kw. generator, together with the necessary auxiliary apparatus, and to keep this plant in operation until the permanent plant could be built and a similar unit installed, whereupon the apparatus in the temporary station would be removed to the permanent power house.

Early in February work on the temporary power house was abandoned, as it had been decided to build the entire project, and work was begun on the excavation necessary to provide a uniform gradient of 0.3 per cent. for the pipe line.

Tile drains of 12-in. diameter were put in at the places where fills were to be made. The tile was laid in a bed of clean sand or gravel, and the joints cemented. Small

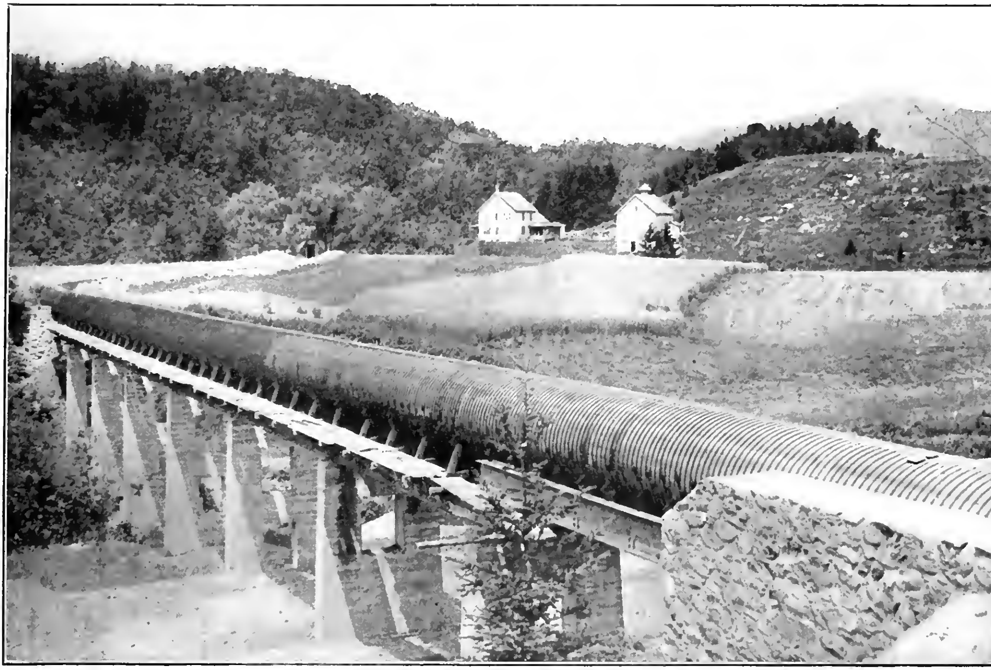


Fig. 2. Concrete Trestle Supporting the Penstock

At a point near where the wooden and the steel pipes join, an equalizing tower 14 ft. in diameter and 90 ft. high is located. The elevation of the bottom of this tower is 950, or 16 ft. above the center line of the end of the wood pipe, and the top of the tower is 19 ft. higher than the flashboards at the dam. This tank consists of one 10-ft. ring at the bottom and sixteen 5-ft. rings above. Each ring is made up of three segments, bent and dipped before shipping.

About Jan. 1, 1914, it was decided to undertake the construction of part of this development by the company forces, as it had a contract which stipulated that from July 1, 1914, it was to deliver a maximum of 600 kw. To live up to this agreement, provision was made to build the main penstock from the dam to a point about 6500 ft. distant, where at *D* a right-angle turn was made, and by running a distance of 1080 ft. a static head of about 200 ft. would be available. It was intended to set up at this point one of the two 1875-hp. turbines and a

rubble walls were built at the intakes and outlets of these culverts.

The wood-pipe line crosses East Creek twice, requiring two trestles, and also crosses a small brook. The trestles have rubble abutments, and the intermediate piers are of a uniform type, being 2x8 ft. at the top, with the front and back vertical and the sides battered ½ in. per foot from the top. They are of 1:2:4 gravel concrete, reinforced with vertical and horizontal bars. Fig. 2 is a photograph of the largest trestle.

The Chittenden dam is 1000 ft. higher than Rutland and 10 miles distant; the power house is 500 ft. higher and 7 miles distant. With the exception of about two miles near the city, the roads are poor. The freighters hauled at the rate of $3 per ton, and in all about 2000 tons had to be moved. The 30-ft. lengths of steel pipe varied between 3¼ and 5 tons.

About 40 per cent. of the wood stave line was composed of curves. With the exception of the stretch between *A*

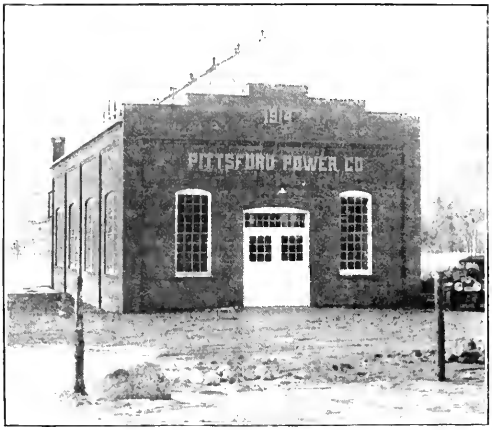


Fig. 3. Chittenden Power House

and B, all curves were either 360 or 300 ft. radius. In the locality mentioned there were some curves of these radii, but also a few sharper ones, notably one at about 175 ft. radius. The average construction progress on curves was about 200 ft. per day of 10 hours, and on tangents about 300 ft. The best day's work was 420 ft., made on a tangent where the staves averaged about 25 ft. in length.

At points where the stave pipe joined the steel pipe, the latter had the rivets countersunk for a distance of 4 ft. from the end, and presented a smooth outside surface for the staves to be fitted over.

It became evident in the latter part of May that the permanent power house could not be in operation by July 1, and so it was decided to build the temporary installation. Therefore, work was resumed with a view to getting in the foundations for the turbine and generator.

At the point D, Fig. 1, a steel tee had been inserted in the main line, and from this a 3-ft. penstock line 1080 ft. long, of which the upper 580 ft. was of spruce and the lower 500 ft. of $\frac{1}{4}$-in. steel plate, single lap, with $\frac{5}{8}$-in. rivets, was built. The spruce staves were milled by the company, and one-piece bands were used. The steel pipe was sublet to a local firm, which made it right at the site of the work.

The ends of the steel tee were punched for $\frac{5}{8}$-in. bolts on 3-in. centers and the staves of the penstock were bolted to the steel tee. At the back of the tee a connection was made to a 2-ft. diameter steel pipe, 80 ft. high, erected to fulfill the function of a surge tank and vent.

About three feet from the downward end of this steel tee a 5-ft. diameter $\frac{1}{4}$-in. steel boiler head was set up as a bulkhead to divert the water through the temporary power-house penstock and to permit turning on the water before the rest of the line was finished. Oakum was packed in wherever possible between the bulkhead and inside of the pipe.

The temporary plant was in operation until Oct. 1, at which time the machinery was dismantled and placed in the permanent plant. The penstock was taken apart and utilized at Molly Brook, where a small collecting basin was built at an elevation of 80 ft. above the penstock at that point and the water conveyed through the 3-ft. penstock into the main pipe line.

The steel pipe was placed alongside the trench by the

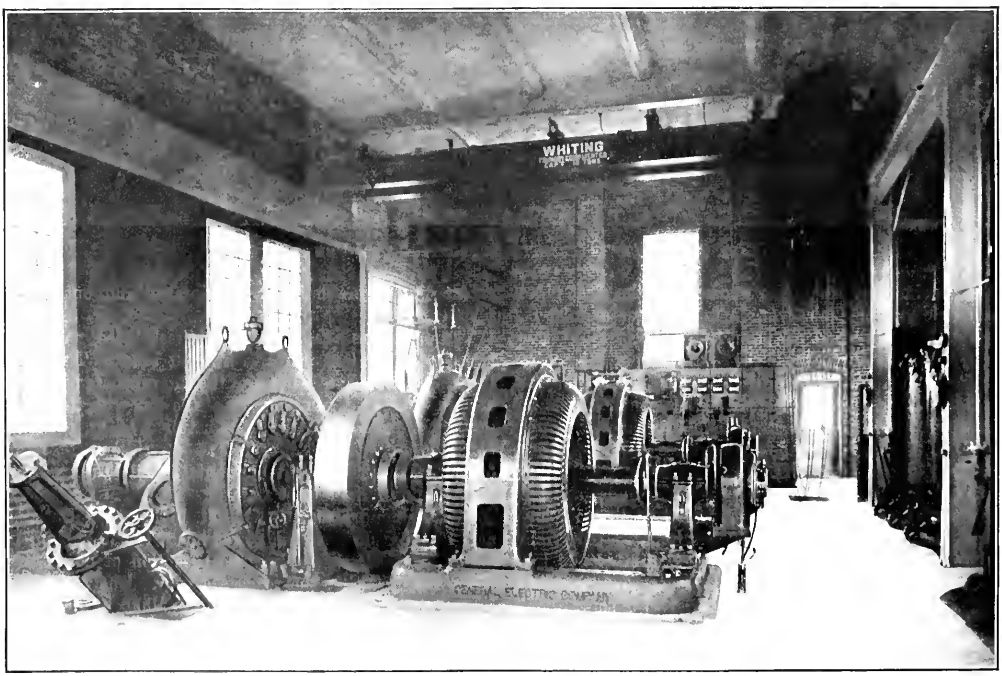


Fig. 4. Interior of the Chittenden Power Plant

company and the pipe contractor's gang rolled the lengths in the trench and used two small derricks to aid in bolting up.

The reaming, riveting and calking followed in the order named; an expansion joint was placed 1418 ft. from the dam to allow for movement of the pipe previous to filling it with water and covering it.

The surge tank is on a rocky knoll at the point *B*. The concrete foundation is, on an average, 3 ft. thick, and six 2½-in. stay-bolts, fitted into holes drilled in the rock and also embedded in the foundation, provide against movement. The connection between the penstock and the tank consists of a 18-in. steel pipe. Between this pipe and the end of the wood pipe, a distance of about 10 ft., is a 60-in. butterfly valve. At the bottom of the penstock, just in front of this valve, is a 12-in. blowoff valve designed to pass such water as might leak past the butterfly, so that no water could leak down the pipe when not so desired. There are manholes in the steel pipe near the butterfly valve and at two intermediate points and the pipe may also be entered through the turbines.

The surge tank has a manhole near the bottom, and a ladder outside affords access to the top. After testing, a frost casing 18 ft. in diameter, or 4 ft. larger than the diameter of the tank, was built. Old 2-in. planks of various widths were used, butted off square without the edges being beveled radially. The first set was placed so that adjacent pieces broke joints, nailed plumb in place, and then ⅝-in. bands on 2-ft. centers were clinched tight. The remaining sets were easily added. At the top is a silo roof, in which a door is arranged to admit air if the drawing off of the water should tend to form a vacuum. The frost casing was covered with a coating of cement-lime plaster applied to a wire lath as a protection against fire and decay; provision was made for heating during the winter months.

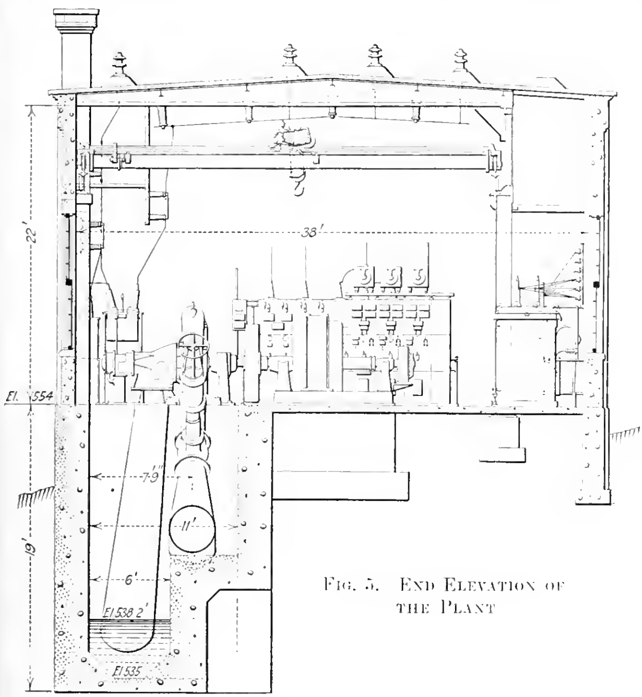


Fig. 5. End Elevation of the Plant

Power House

The permanent power house is a single-story structure 38x71 ft. inside and 22 ft. high (Fig. 3). The foundation walls are of 1:2:4 gravel concrete of an average depth, excepting the south wall, of about 6 ft.; they are 18 in. thick and rest on a 12-in. footing course 3 ft. wide. The south wall, which forms one side of the tail race within the building, has a depth of from 12 to 19 ft. and is 30 in. thick.

The walls of the building consist of a 12-in. double-faced brick wall, pilasters 28 in. square being introduced so as to divide the north and south walls into four bays and the east and west into three bays.

The roof is framed of three transverse girders, between which are standard I-beams, and is covered with a 4-in. concrete slab reinforced with triangle-mesh reinforcing. The roof is waterproofed with six layers of tarred felt and stone screenings.

The steel penstock enters the building normal to and through an opening in its front wall, and about eight feet from the south wall. Three nozzles lead from the penstock to feed the turbines; they are 24 in. inside diameter and flanged to take a 24-in. valve, fitted both for hydraulic and hand operation. When the pipe had been filled and tested the penstock was heavily anchored with concrete.

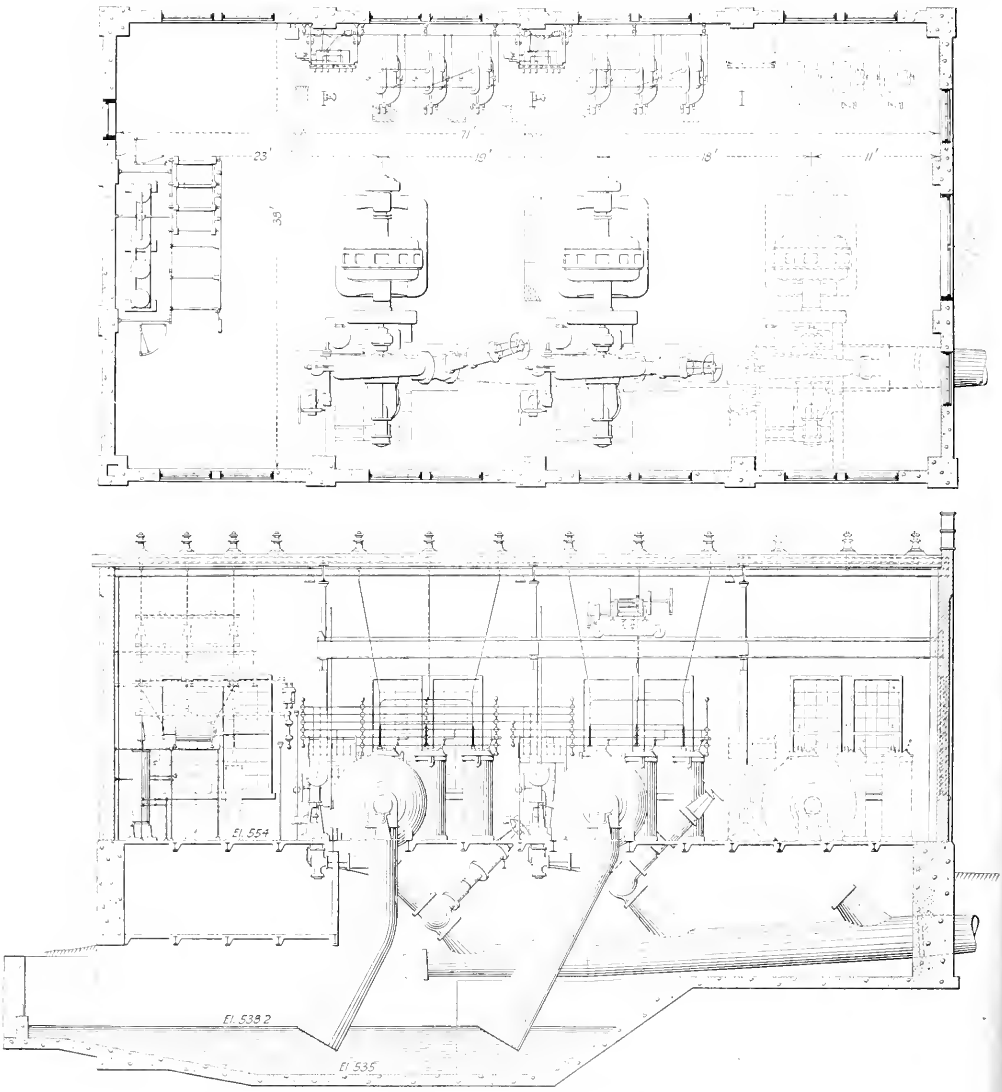
The tail race lies at the south side of the building and is 11 ft. wide, and 18 ft. deep. Over the west or back end of this building was built a small room, in which is installed a low-pressure boiler for heating the building.

The turbines are placed over the tail-race, each being carried by a pair of 12-in. H-beams, secured by anchor bolts and concreted in. Space has been provided for three units, although at present only two have been installed. The turbines, of the Francis type with wicket gates, are of 1850 hp. at 720 r.p.m. under a 430-ft. head at full gate opening. All the gate-operating mechanism is on the outside of the flume, and is controlled by a governor of the direct-connected type, arranged for electric control. The runner consists of a bronze runner band with a cast-iron hub, the latter being securely keyed to the turbine shaft. The spiral flume is made of a single iron casting and has the form of a true evolutionary spiral. The gates and the guide ring are made of cast steel, and the gate ring of cast iron. The turbine shaft is made of hammered steel, 6 in. in diameter on the driving end and 4½ in. on the remote end. The driving end of the shaft is fitted to the hub of the 5-ft. 9-in. cast-iron flywheel, which weighs about five tons. The remote end rests in an end-thrust bearing arranged to operate in a bath of oil.

The draft tube is about 15 ft. long and has a diameter of 48 in. at its lower end. To protect the line against undue rise in pressure caused by the action of the governor under the varying conditions of load, a relief valve capable of discharging 30 cu.ft. per second is installed.

The side of the flywheel remote from the turbine is fitted with a flange, to which a forged flange on the generator shaft is fitted to couple the two together.

An interior view of the power house is shown in Fig. 4. Figs. 5, 6 and 7 are plan and elevation of the power plant. Just outside the power house there is inserted in the pipe line a venturi meter with a 52-in. inlet and 27x42-in. outlet. Both the inlet and outlet ends of the castings are flanged, and faced and drilled to take the $\frac{9}{16}$-in. flanges of the adjacent steel pipe. The meter is connected to an automatic register indicator recorder.



FIGS. 6 AND 7. PLAN AND SIDE ELEVATION OF THE HYDRO-ELECTRIC PLANT

ELECTRICAL EQUIPMENT

The station is designed for a maximum continued capacity of 3000 kw. at 44,000 volts and 80 per cent. power factor, this energy to be generated by three units and delivered through two 44,000-volt feeders. Two units and one feeder are now in regular operation, and the third unit and second feeder will be added when necessary to take care of the future increase in load.

Each generator is rated at 1250 kv.-a., 2300-volt, three-phase, 60 cycles; and with a 25-per cent. overload for two hours the rise in temperature is guaranteed not to exceed 55 deg. C. above the room temperature of 25 deg. C. Each generator has its own direct-connected exciter, operating in parallel at 125 volts.

There are at present two banks of transformers, each consisting of three single-phase, 100-kv.-a., 2300-44,000-volt, water-cooled transformers, and with a 25-per cent. overload for two hours, the rise in temperature is guaranteed not to exceed 55 deg. C. above a room temperature of 25 deg. C. Cooling water is supplied from the penstock at a reduced pressure.

The switchboard is of marble and consists of exciter feeder panel with voltage regulator, generator, lighting and a blank generator panel. All control and instrument wiring is installed in iron conduit laid in the concrete floor. As the oil switches are remote-controlled, 125 volts is the maximum on the switchboard.

A 2300-volt bus of copper tubing is supported vertically on the north wall back of and above the transformers. The generators connect to this bus by means of lead-covered, varnished-cambric insulated cables laid in fiber ducts below the main floor, and the usual oil switch and disconnecting switches.

Each transformer bank is connected to the 2300-volt bus through disconnecting switches and to the 44,000-volt outside bus on the roof by means of copper tubing through the roof bushings and a three-pole air-brake switch, this switch being hand-operated from the station floor.

The 44,000-volt bus, three-pole, air-brake switches and lightning-arrester horn gaps are mounted on pipe framework supported on the roof, the entire roof being used for this purpose.

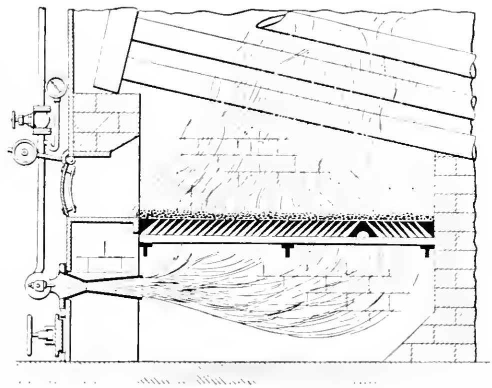
An iron stairway at the west end of the building provides easy access to the roof through a door and landing at the main-floor level.

Electrolytic lightning arresters of indoor type are connected to the horn gaps through roof bushings. The present feeder connects to the 44,000-volt transmission line through a three-pole, 44,000-volt, indoor-type, remote-controlled auto-oil switch and the usual disconnecting switches and choke coils.

The Pittsford Power Co. development was designed and constructed under supervision of W. S. Barstow & Co., engineers and managers, of New York City.

Poillon Furnace Grate

The Poillon grate illustrated herewith is designed to burn fine dust, lignite, coke and other grades of coal. The particular feature is that the direction of burning gases is from the ends of the grate toward the center of the furnace.



Poillon Furnace Grate

In the ordinary furnace the liberated gas flows toward the bridge-wall and upward. With this grate the currents are from the front of the furnace toward the rear and from the rear toward the front, caused by the angle of the air spaces in the grate. The result is that the liberated gases from freshly fired fuel at the front mingle with the hot gases from the rear end of the furnace, and their combustion takes place before striking the cooling surface of the boiler tubes.

The mingling of the two currents distributes the flames over a large tube area and prevents the hottest flames from striking the tube in the form of a jet, as would be the tendency were they to go to the tubes with no interruption.

As illustrated, the grate (which is placed on the market by Julian Champeaux, 36 Downshire Hill, London, N. W.) is used in connection with a blower.

PRINCIPAL EQUIPMENT OF CHITTENDEN HYDRO-ELECTRIC POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Turbines	Francis, wicket gate	1850-hp.	Driving main generators	430 ft. head, 720 r.p.m	S. Morgan Smith Co.
2	Generators	Alternating-current	1250-kv.-a	Main units	720 r.p.m., 2300 volts, 3-phase, 60-cycle	General Electric Co.
2	Governors	Direct-connected		With main turbines	Electrically controlled	Lombard Governor Co.
2	Exciters	Direct-current		With main generators	Coupled to generator shafts, 125 volts	General Electric Co.
1	Switchboard	Marble		Electrical control of units		General Electric Co.
6	Transformers	Water-cooled	400-kv.-a.	Stepping-up current	2300-44,000 volts, single-phase, 60-cycle	General Electric Co.
	All electrical apparatus in power house, such as switches, lightning arresters, etc					General Electric Co.

Illumination is obtained from six 250-watt tungsten lamps in deep-bowl reflectors hung close to the ceiling, the outlet boxes and connecting conduit for wiring being cast in the concrete roof. Extra illumination and plug receptacles for portable lamps are conveniently distributed on the walls of the building. Outdoor lighting is provided for the roof by means of street lighting fixtures, thus assisting greatly in inspection and repair at night.

Illumination is controlled from the eight-circuit lighting panel, which is a part of the main switchboard. A double-throw switch mounted on this panel enables the lighting supply to be taken from the 2300-volt bus through a 3-kw. transformer or from the exciter bus.

The permanent power house was placed in operation about Oct. 1, 1914, and the unit from the temporary plant was set up during that month.

Boiler Accidents—A report submitted at the convention of the American Society of Mechanical Engineers in New York City last December contained the following statement:

Every year there averages in the United States between 1300 and 1400 serious boiler accidents, of which 300 to 400 are violent explosions. These accidents kill between 400 and 500 persons, injure 700 to 800 more, and destroy more than half a million dollars' worth of property. In a single explosion, that of the R. B. Grover Shoe Co., at Brockton, Mass., 58 persons were killed, 117 more were injured, $250,000 worth of property was destroyed, and an aggregate of $280,000 was claimed in the personal injury and death suits that were brought. In a period of 46 years, since 1867, over 10,000 people have been killed and over 15,000 injured in boiler explosions

Pre-Efficiency

By Geo. F. Willis

SYNOPSIS—The importance of the preliminary work while laying out a power installation. Only by studying the conditions and selecting the equipment to suit can one expect to have a truly efficient plant.

This is the day of efficiency in all classes of manufacturing, and the successful manufacturer looks for it all along the line. After a plant is built, the operation is closely watched in order that efficiency in all departments may be secured. Many schemes, from piecework to bonus payment, are used, all to add to the one proposition—efficiency.

But how few manufacturers or owners go at this matter from the first inception of the plant! It is decided to build a factory for a certain purpose, costing say $250,-000. It is easy to find architects competent to build the housing, and the plans are made, submitted and accepted. But the power plant, the real heart of the proposition—the boiler and engine equipment, the electrical power to be used for lights and motors, the pumps, economizers, heaters, condensers—all this is usually left to the architects, who are the last people who should have any say as to this part of the outfit, as their experience and efficiency are practically limited to the building itself. They work out the balance of the scheme as best they may, as an accessory to the original in which they are most interested, and men are too often influenced by personal acquaintanceship and prejudice.

The use of oil and gasoline engines, producer-gas equipment, electrical driving and its advantages and disadvantages—these problems are neither thoroughly considered nor gone into expertly, but are usually left to the good or bad judgment of the original designers of the building itself. When it is known that in building a factory costing the amount mentioned, there might be made a saving of 10 per cent., or $25,000, by calling in engineers in the special lines mentioned, their cost being but a small part of the saving named, it is curious that such technical ability is seldom called for, and the factory is built without the owners knowing what might have been saved for the same capacity or what might have been added to the capacity reached, by the advice of technical experts in the particular line for which the factory is built.

The writer is often confronted by the advertisement of some manufacturer of belts, for instance, who will take a whole page in some technical journal to tell about a big belt he has just supplied to some concern. This will be a triple leather belt, 84 in. wide and 160 ft. long, we will say, and he goes on to tell how many steer hides it took to make it, how much it weighs, what it will drive, etc. In the writer's opinion, anyone shows poor judgment who uses a belt any wider than, or even as wide as, 24 in. He also believes that manila-rope transmission for anything in the way of main drives from 50 hp. up is cheaper and better than any belt drive. In the case of such a belt as mentioned, the saving in the original cost by using ropes would be some $2000, and the ropes would have as long life as the belt, with less slippage and a smoother and more positive drive all around. In such a case it is probable that the designers of the plant have seen so many wide belts in other plants that they have no idea anything else could be used. It is a case of mental suggestion.

Take the case of a company building a $75,000 sawmill. It is willing to and usually does build the plant from the plans of the maker of the machinery to be used, who is naturally a much interested party. As a judge of the design the purchaser calls in his old foreman, who has been with him many years, and as he ran the old plant successfully he is considered an authority. He well knows every weak place in the old plant, and he is firmly resolved that in case he has anything to say about the new one, these weak spots will be eliminated. So when the new plans are offered him for his criticism, he rigidly turns down anything that looks like the trouble spots he had to contend with for so many years, and finally approves the plans submitted. He does not know what new troubles the new plant will bring, and he is not capable of selecting from the mass of technical details of machinery offered the best to be used. So the concern buys, and the mill is built. It may run to the satisfaction of the owners, but like a doctor's mistakes, all that have been made are buried; and while it might have been possible to build the same mill for less money, to build a better mill for the same money, to build a mill at the same cost which would produce the same amount of lumber with a few less hands, all this is unknown, and the expert engineer was never called in, everything being left to the judgment of one man who knew all about one mill and nothing of any other.

The writer's experience of something like twenty-five years in designing and building plants has shown him that efficiency rarely begins at the commencement of the operation—where it more properly belongs than at a later period—and that nine out of ten plants are built from crude ideas of owners and employees. One manufacturer who intends building is positive that he will use electrical transmission throughout. He does not know exactly why, but he has read of the great strides that have been made in introducing this system, and as a factory a few blocks away has just been completed and this transmission is used throughout, why should not he use it? It may be that this is the least desirable system for his special requirements, but he does not call in a transmission expert to secure his views and advice. The electrical people are willing to meet him more than half way and confirm his views and wishes. So he spends much money for a power-transmission scheme that does not suit his conditions and is satisfied forever afterward because his factory runs and produces.

No one maker of machinery builds a full line of the best. He may have one or two machines that cannot be equaled, one or two that are about as good as others, and the rest of his line not so good as those built by his competitors. But the tendency is to buy the full equipment from one maker, on a blanket proposition covering the full list of machines required. This, in a way, largely depends upon the salesman that secures the order. Many times the writer has sold the complete equipment for a plant on the strength of one machine which his company originated, and built better than anyone else. The fact that this machine cost several hundred dollars more to build than was got for it mattered not, as this was made up on the remainder of the order. Six out of ten times we sold the power plant, which we did not build at all, and which we bought as cheaply as we could so long as it approached the requirements—said requirements being suggested by ourselves, of course. Had a competent engineer been called in on these jobs, it is likely we would have secured the order for the one machine we built better than our competitors and that the rest of the equipment would have been ordered from other makers—as it should have been.

Were a man to contemplate building a home to cost $75,000 or an office building to cost $250,000, he would first go to the best architects he knew of to procure the plans. They would supposedly have at their command technical engineers who were thoroughly conversant with all building requirements and whose efficiency would be added to that of the members of the designing staff. The plans would be prepared with great care and thoroughness, and after a careful analysis by the owner, would be accepted and built from. Were the same man to contemplate the building of a sawmill costing as much or more, he probably would leave the important part of the whole proposition to "Jim," who had run the old plant for thirty years and who should know just what was needed in a new one.

As to power efficiency, the proper kind and character of the boiler plant, whether steam or gas or electricity should be used, all swings on the opinion of the old employee, whose influence is not to be laughed at either. Good or bad, his advice is followed, greatly to the embarrassment of the expert, should one be called in.

In the city in which the writer lives, is one of the largest and, supposedly, one of the most advanced companies in the world, which has become famous by dividing its profits with its employees, with which strikes are unknown, and whose power plant is one of the sights of the city. It has been shown by technical engineers of high standing, after an investigation lasting for weeks, that by scrapping its beautiful engines—nickel-plated and in a room as beautiful as any parlor—the company could make a saving in fuel and upkeep amounting to many thousands of dollars yearly. Would it do it? No, because a man who had been for years close to the president and had sold the company its valves and small equipment advised against it—said the plant was all right as it was and that the experts did not know what they were talking about. His advice "went," and no change has been made. This simply goes to show the small amount of credence given the technical engineer in matters within his own province, and on which he has absolute information.

In the really great and advanced plants engineers may be found who are employed at salaries running up to $25,000 a year and more, and they are cheap men at the price. But in the half-way plants, the ones costing up to the half-million mark, where the technical engineer is nearly always badly needed, he is seldom called in. It is easy to be too technical, so to speak, but the combination of fifty-fifty—half experience and half technical knowledge—will, when secured for even a small plant, well repay the owners, not only in the original cost, but in the following years of operation.

Just for Fun

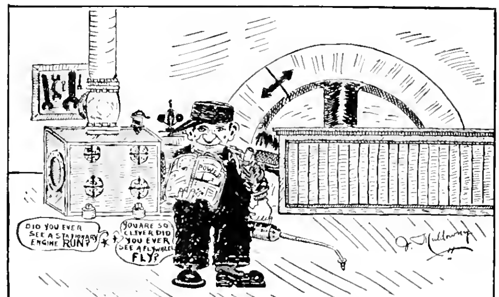
[*More stories of stupidity and ignorance competing with "Some Original Ideas," as printed Jan. 19, 1915.*]

"What's the matter?" asked the superintendent of the second-class licensed engineer on hearing the receiver relief valve blowing fiercely on the 1200-hp. compound engine.

"I guess the exhaust pipe has burst between the engine and the condenser."

"Well, the vacuum is up to 27 in., isn't it?"

But the engineer was making haste to start the larger engine and did not wait for argument. The superintendent, who had formerly been the chief in that station, walked over to the low-pressure side of the engine and pushed the reach rod up forward on the governor, and the relief valve stopped blowing. The engineer returned hastily to see what had caused the engine to become quiet so suddenly. He was cautioned not to tell anyone that he thought the exhaust pipe on a condensing engine had burst with 27 in. of vacuum, but thereafter to watch the governor on the low-pressure side to see it did not unhook again, leaving both steam valves closed.—*R. A. Cultra, Cambridge, Mass.*



A WELL KNOWN EXPRESSION
"MORE POWER TO YOU"

A young man recently out of college secured employment as helper around a power plant in an industrial establishment. One day the engineer was called to another part of the plant and left the young man alone in the power house.

After a time the engineer noticed a cloud of steam coming from the blowoff pipe. He did not pay much attention to it at first, thinking that the young man had too much water in the boilers and wanted to blow down a little, but when the blowing had continued for some time he started for the power house to investigate.

Upon arriving, he found that a gage-glass had broken and that the helper had the blowoff valve wide open. When questioned concerning his reason for having the valve open, he said that he wanted to let out the pressure so that he could put in a new glass.

It might be well added that the young man had not studied engineering while at college, but is now a good engineer and has had some six or eight years of experience in the "school of hard knocks" since the incident related.—*Earl Pagett, Coffeyville, Kan.*

Diesel-Engine Installation at Palo Alto

By Herbert Haas

SYNOPSIS—By installing a 300-hp. Diesel engine to carry the day load and using one of the steam units to help out on the peak, a saving of about $6000 has been effected. Heavy California residue is used.

In 1913 the City of Palo Alto, Calif., contemplated replacing its old and rather wasteful steam engines with a steam turbine of excess capacity above the equipment then in operation, which consisted of a cross-compound, slide-valve engine coupled to a 200-kw. alternator, a similar engine driving a 100-kw. alternator, both operating noncondensing, and a single-cylinder, simple engine, with Corliss valve gear, belted to a 50-kw. generator. The two larger engines furnished practically all the load, which for a short period, between 7 and 10 p.m., rose to 330 kw. The steam turbine was to be a 500-kv.-a. unit, operating condensing, its excess capacity being intended to take care of expanding power and light business.

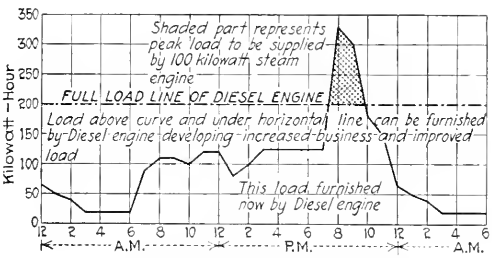


Fig. 1. Load Characteristics for 24 Hr.

Fig. 1 shows the load characteristics during 24 hr., based on a yearly average of the load in 1912. It will be noticed that it is a typical lighting load, only a portion of the power being used in the daytime to operate pump motors. With a load factor, then, of about 30 per cent., this would have become still more unfavorable after the installation of a 500-kv.-a. turbine, for the load would have been around 20 per cent. of the rated capacity of the turbine during the greater part of the time.

Therefore, the writer advocated the installation of a Diesel engine, which, to save in initial investment, was to be of moderate size only, sufficient to carry the entire load except between 6 p.m. and 10 p.m., when one of the existing steam engines was to operate in parallel with the Diesel engine to supply the peak load. The average fuel consumption of the steam plant was 11,000 lb. per day for an average output of 2620 kw.-hr. per day, or 4.2 lb. of fuel oil per kilowatt-hour. It was figured that the Diesel engine would furnish 2400 kw.-hr. (operating at fractional loads, as shown in Fig. 1) with a fuel consumption of 1800 lb., and that the 100-kw. engine unit, operating at full load, would furnish the other 200 or 250 kw.-hr. with a fuel consumption of about 4 lb. per kw.-hr., or 800 to 1000 lb. of fuel oil, in addition to a moderate amount of oil to keep one of the boilers always under steam as a stand-by. Thus, about 22 to 24 bbl. of fuel oil, costing 90c. per bbl., could be saved per day. Against this saving had to be charged interest and amortization on the capital invested in the Diesel engine plant, the slightly higher cost of cylinder lubrication and maintenance. It was thus figured that a saving of $6000 to $7000 per year could be made by the installation of a Diesel-engine set. The operating force was not increased, so the labor item remained the same. It will be seen from the load curve that the Diesel engine would be operating only at about 50 per cent. of its capacity during the day, so that considerable reserve capacity was available for a future increase in load during this period, and any increase in the peak load could still be furnished by the existing steam equipment.

One of the requirements of the engine was the burning of California crude oils or residues, of the same or similar quality as that which is burned under the boilers. The power plant is some distance from the railroad, the fuel oil being pumped to it through a pipe line, which would make it difficult to supply two different oils, one for the boilers and the other for the Diesel engine.

In view of the extensive development of this type in Germany, and after thorough investigation, the Körting Diesel engine was selected, as this engine was found to be giving excellent service in Mexico, running on the heavy asphaltic oils and residues similar to the California oils. The engine is of horizontal construction and has four cylinders. The shaft is extended, and carries the flywheel and the alternating-current generator between the left outer main bearing and an outboard bearing. Beyond the outboard bearing there is a further shaft extension, to which are keyed the armature and commutator of a 10-kw. exciter. The shaft is forged in halves, coupled together between the halves of the engine. To the right-hand shaft end is bolted a crank disk, from which is driven the air compressor. Each shaft section has two cranks, set at 180 deg. The generator is a two-phase, 60-cycle, 40-pole Fort Wayne machine, wound for 2300/2400 volts, and rated at 250 kv.-a., which at 80 per cent. power factor is equivalent to an output of 200 kw.

The pistons are of trunk pattern made especially long to reduce pressure exerted through the crank and piston pins and prevent wear of the cylinder liners. The valves are seated in the cylinder heads, and are all easily accessible, being mounted in individual cages, and can be quickly exchanged. This is of importance, as the exhaust and fuel-injection valves have to be cleaned monthly; spare valves are put in their places and the removed valves are then cleaned at leisure, and kept in readiness.

The governor and valve-gear shafts are operated directly from the main shaft through helical gears running in oil. The governor shaft operates the engine governor, lubricating pumps, and fuel pumps. Of special note is the construction of the fuel pump and the fuel injector. The pump does not have to force the oil against the injection air stored around the fuel-valve needle at a pressure of 800 to 900 lb., a practice common to many

Diesel engines. Instead, the pump works at just enough pressure (only a few pounds) to lift the oil into a chamber in the fuel injector during the suction stroke of the piston. The governor can, therefore, act directly on the pump plunger and vary its stroke according to the exact fuel requirements of the engine, proportionate to its load. The fuel injector has no needle valve, but consists of an open Körting atomizing nozzle. A few degrees before the completion of the compression stroke, a valve in the fuel injector connecting with the injection-air supply pipe is opened, admitting the highly compressed air, at 800 to 900 lb. which carries the fuel-oil charge (stored in the injector during the suction stroke) into the cylinder, at the same time completely atomizing it.

Each cylinder has its individual fuel pump, two pumps being mounted on each valve-gear shaft. The Hartung governor acts on all four pump plungers simultaneously, through wedges which increase or decrease the throw of the plungers with an increase or decrease in the load of the engine. This method of governing is very sensitive, the engine adjusting itself instantly to changes in load.

Another feature worthy of note is the method of starting. Instead of using high-pressure air, which takes considerable power to compress, the engine is started with air at 220 lb. and can be started with a pressure as low as 110 lb., if necessary. The air is stored in a sheet-steel receiver. This method of starting is made possible by having the exhaust valves open during the compression stroke, so that the cylinders work against atmospheric pressure only; when the engine is up to speed, the sequence of the valve play is changed, the air is compressed, and the fuel charge is admitted, the exhaust valves then discharging the products of combustion.

The air for starting the engine and the injection air for atomizing the fuel and forcing it into the engine cylinder is furnished by a three-stage compressor, the low-pressure stage being vertical, the intermediate and high-pressure stages being tandem horizontal cylinders. Between each stage there in an intercooler and oil separator, and the compressor cylinders are all water-jacketed for cooling. The interposition of coolers and oil separators is an important safeguard to prevent explosions. The injection air is stored in two wrought-steel bottles, 8-in. diameter by 6 ft., of which one only is in use, the other acting as a reserve.

The oil flows to the fuel pumps by gravity from a supply tank holding one day's supply and supported on a shelf attached to the wall of the engine room. It is pumped to this tank from the concrete main storage tank, which is built into the ground outside the power house. This fuel oil, being a residue of California crudes (topped oil), has to be heated on account of its high viscosity. This is usually done by using the heated jacket water of the engine. For starting, a gas oil is used (Standard Oil Co.'s Star fuel oil) and, after a few minutes' operation, the engine and circulating water are warm enough to substitute the residue. At Palo Alto, however, the latter is now heated by steam and the engine runs continuously on the residue.

The air intake for the engine and for the compressor is on the outside of the power house, the air main and individual air conduits leading from it being built into the engine foundation and connecting with the air-intake pipes of the cylinders. The exhaust gases are passed through two double silencers and then through pipes leading under the boilers, from which they are carried off by the boiler stack. The pipe connections between the exhaust ports and the silencers are water-cooled to prevent excessive radiation and heating of the space immediately around the engine heads.

All internal lubrication is supplied by two Bosch lubricating presses operated from the governor shafts. The

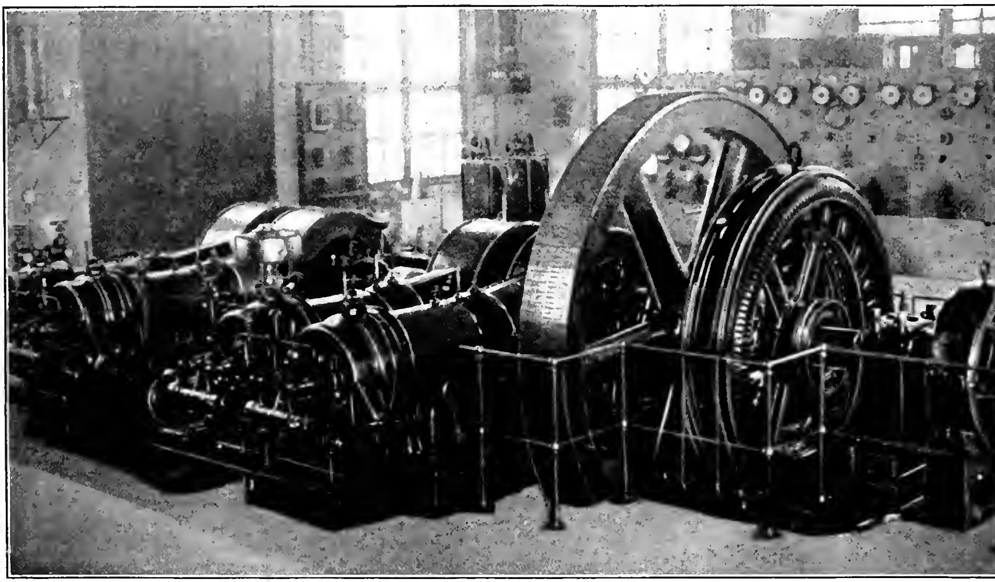


Fig. 2. Installation of Körting-Diesel Engine at Palo Alto, Calif.

piston pins are also lubricated by these. The lubrication of the main bearings and of the crankpin bearings is supplied by a geared lubricating pump, which forces a stream of oil to each bearing, collecting rings preventing any being spilled. The oil is fed to the crankpin bearings by lifting rings. All oil is collected in the crank case, flows through a filter and cooler, and is returned to the main container, located below the floor. The bearings are also provided with individual glass reservoirs and rings for use in case the lubricating-oil pump should fail.

For testing the engine before shipment, 4 tons of Standard Oil Co.'s Richmond fuel oil (a residue) was

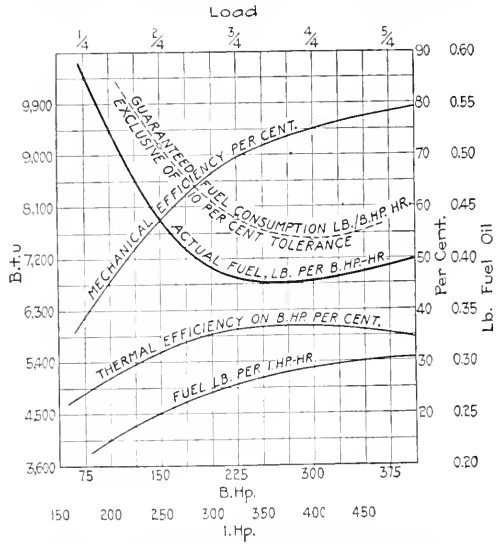


Fig. 3. Performance Curves of 300-Hp., Four-Cylinder Körting-Diesel Engine

shipped to Germany. R. E. Mathot, of Brussels, acted as consulting engineer for the City of Palo Alto, and conducted the tests at the works of the builder. The principal test data are here given, and the engine performance is shown in Fig. 3.

The California fuel oil (Richmond Fuel Oil) had the following properties:

Lower heat value	17,741 B.t.u.
Gravity at 59 deg. F. (15 deg. C.)	0.948
Flash point in open air	185 deg. F.
Boiling analysis—	
Oil begins to boil at	223 deg. C
Amounts distilled in per cent. of the volume at 250 deg. C.	1.5
at 300 deg. C.	12.5
Contents in ash, per cent	0.01
Contents in coke, per cent	5.29
Contents in asphaltum, per cent	1.65
Contents in water, per cent	0.1
Contents in insoluble matter, per cent	0.002
Viscosity (Engler) at 20 deg. C	129.3
at 50 deg. C	12.9
at 80 deg. C	3.48
Chemical analysis—	
Carbon, per cent	86.59
Hydrogen, per cent	11.47
Oxygen and nitrogen, per cent	1.33
Sulphur, per cent	0.61

Note—The oil is very high in constituents, boiling above 300 deg. C., also high in coke.

The guarantees for fuel consumption made by the builders, with a 10 per cent. tolerance in their favor, with oil having a mean lower heat value of 18,000 B.t.u. per lb. per b.hp.-hr., were: At full load, 0.420 lb.; at 3/4 load, 0.0440 lb.; and at 1/2 load, 0.510 lb.

The fuel consumptions determined by test, using the oil with a heat value of 17,741 B.t.u. per lb., were as follows: At full load, 0.388 lb.; at 3/4 load, 0.385 lb.; and at 1/2 load, 0.439 lb.

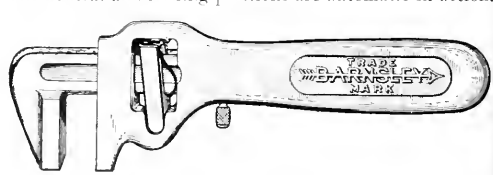
These figures are lower than those guaranteed, especially if the difference in heat value of the oil used is taken into consideration. Indicator diagrams were taken simultaneously on all four cylinders, also on the low and intermediate pressure stages of the air compressor. The small clearance space in the high-pressure cylinder of the compressor did not permit of attaching an indicator to it. The fuel consumption given includes all work done by the engine and the compressor and represents the net work delivered at the shaft.

Since the engine has been installed and its output has been checked by the output of the generator, the average fuel consumption falls within the guarantee. Some difficulty was at first experienced in finding a cylinder oil which would stand the high temperature in the engine cylinders and compressor. This was met by lowering the cooling-water temperature issuing from the jackets, and principally by experimenting with different oils until one was found that had the desired properties and gave satisfaction. The most gratifying result of the installation is the fact that the predicted saving has been fully realized, the City of Palo Alto saving about $20 daily above its previous practice; and the work of Messrs. J. F. Byxbee and A. V. Youens, representing the City of Palo Alto, is an example of what a progressive municipality under proper guidance can do in furnishing cheap lighting and power service.

Quick-Acting Wrench

The wrench shown has instantaneous adjustment. It is operated by placing the object to be turned between the jaws and pressing the movable jaw in, or drawing it in with the thumb-trigger under the handle, until it strikes the object.

The grip is then maintained and increased by an automatic locking clutch which acts as a cam and has a neutral position that allows the jaw to move freely in and out. The neutral and locking positions are automatic in action.



Automatic Quick-Acting Wrench

The clutch is made of one piece, and with the mechanical principle involved, the harder the pull on the wrench the tighter is the locking action. A slight pressure on the clutch opens the jaw.

This type of wrench is made in several styles by the Automatic Wrench Manufacturing Co., Boston, Mass.

Mouse Caused Plant Shutdown—Recently a dead mouse was discovered between the terminals of a 2200-volt oil switch connected to a 2000-kw. generator in a small central station in the Middle West. The engineer, while attempting to remove the mouse with a pair of sticks, accidentally got it across two exposed parts of opposite polarity, thereby causing a short-circuit, which severely burned him, destroyed the switch and shut down the plant.

Direct-Current Three-Wire Systems

By Gordon Fox

SYNOPSIS—The different methods of equalizing the voltage on a three-wire system, with special reference to the motor-generator set.

In the majority of plants in which direct current is used there are two competing conditions affecting the selection of the voltage. Economy in wiring for motor service demands the highest voltage consistent with reliability and safety, which is commonly considered to be 230 volts at the generator; whereas the lighting layout usually employs tungsten lamps on a 115-volt circuit. These conditions have led to the extensive adoption of the three-wire system. The 115-volt load will ordinarily be much smaller than the 230-volt load, and the unbalancing of the two sides of the low-voltage system is not likely to be great if care be taken in making the wiring layout.

A number of different means are utilized for obtaining the three-wire service and double voltage. The earliest method is but little used. This employed two separate generators, each wound for 115 volts, placed in series. The two machines combine in carrying the load on the outer wires, while each handles its own 115-volt load. The voltage regulation may be manual or automatic. Perhaps the most common present-day application of this system is that in which a generator having a double commutator is used. The armature is wound with two separate 115-volt windings, each connected to one of the commutators on the opposite ends of the machine. The commutators are connected in series for 230-volt service and their common point supplies the neutral. A machine of this kind is represented in Fig. 1.

The most popular means for providing three-wire service is the so called three-wire generator. This is, ordinarily, a standard 230-volt machine in which the arma-

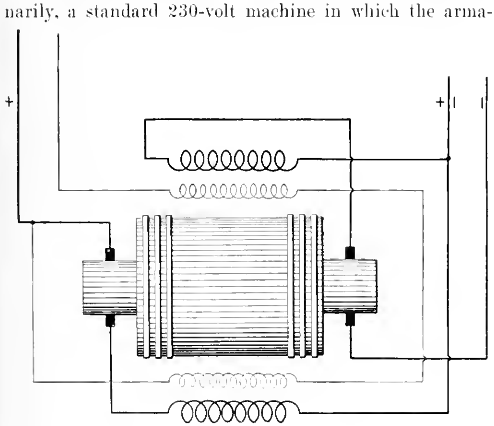


Fig. 1. Three-Wire Generator with Double Commutator

ture is tapped at two or more points 180 electrical degrees apart, the taps being brought out to collector rings. Where the unbalanced load is small two rings will suffice, but if the unbalancing is likely to be considerable it is better to provide four rings and to tap the armature at four points 90 electrical degrees apart, so as to secure a two-phase arrangement. Leads from the collector rings are brought out to a compensator that is merely a reactance coil. An alternating current is collected from the

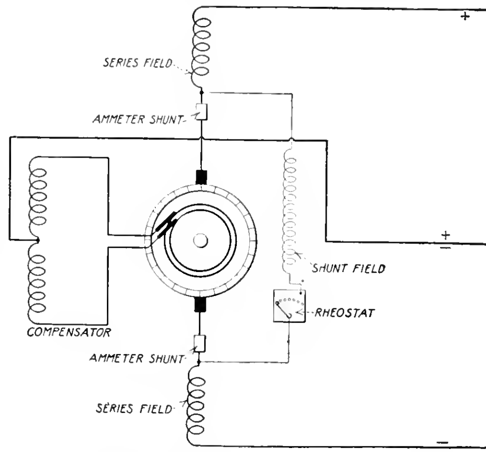


Fig. 2. Connections for Three-Wire Generator

rings and this current magnetizes the reactance coil, inducing a counter voltage such that only a small magnetizing current flows across. The central point of the coil is always the neutral of the system, since it is always half way between symmetrical conductors of opposite polarity. In this manner the half-voltage point is provided. In the case of unbalanced load a direct current passes through the reactance coil and collector rings and part of the armature winding. In a two-phase arrangement the unbalanced load current is distributed over more armature coils, so that heating is more uniform and voltage regulation is better; hence, the preference for this type where unbalancing is likely to be severe. Recently, there have been placed upon the market three-wire generators in which the reactance coil is built into the spider of the armature and the neutral is brought out from the center of this coil by a single collector ring. This makes it possible to tap the armature at more points for a multiphase reactance coil, without the disadvantages of a multiplicity of collector rings.

Three-wire generators are commonly designed and rated for 10 per cent. unbalancing, although sometimes a greater amount is specified. These generators may be flat, drooping or overcompounded in their two-wire voltage characteristic, and they will ordinarily maintain the neutral within a 5 per cent. range. Three-wire generators are connected as shown in Fig. 2, the shunt field being connected across the armature and the series field being divided into two sections, one-half in each side of the line. In this manner the compounding effect is averaged for unbalanced conditions. These machines may be operated in parallel the same as two-wire machines. However, there must be two equalizers because of the division of the series field. In adjusting the compounding of three-wire generators it is necessary to use similar german-silver shunts around each of the series fields, and in proportioning the load division between two machines to operate in parallel it is necessary to adjust the series circuit resistances between both equalizers and busbars instead of just upon one side, as for two-wire machines. When two-wire machines are paralleled the ammeter shunts are placed between the brushes and the series fields to prevent cross-currents from one machine affecting the instruments of the other.

It is possible to provide two-voltage service from a two-wire system by the use of a series of storage batteries connected across the outer lines with the neutral wire connected to the middle point. On balanced load the battery floats across the line. If the load is unbalanced the battery on the heavily loaded side discharges, while that on the lightly loaded side charges. The combined charge and discharge currents flow through the neutral supplying the unbalanced current. The neutral voltage must shift enough to cause this charge and discharge action, so that the regulation is imperfect. The voltage can be adjusted by means of end cells or by the use of a booster.

Double generators or three-wire machines are feasible for plants generating their own power. If only 230-volt power is available and three-wire service is desired, it is necessary to provide a means for locally maintaining the fixed neutral and providing unbalanced current. This is commonly done by the use of some form of balancer. There are several types of such sets, the more common of which will be here discussed.

Motor-generator balancer sets are ordinarily composed of duplicate units direct-coupled and mounted upon a common bedplate. They may be either shunt or compound wound and are sometimes equipped with interpoles. The armatures are wound for half line voltage and are connected in series across the outer leads, their common point being the neutral. The difference in the sets lies mainly in the arrangement of the field connections.

Shunt-wound balancer units may have the fields wound for either half voltage or full voltage. If wound for full voltage the fields are paralleled, and if wound for half voltage the fields may be in series with their central point either connected to the neutral or isolated from it. Fig. 3 shows one connection for a shunt-wound balancer set. With a balanced load both machines run light as motors. With a greater load between the neutral and the positive side, machine *A* acts as a generator and *B* as a motor, the two combining to feed the extra current to the heavily loaded side. The motor armature carries a current greater than that of the generator armature by an amount sufficient to supply the losses of the set. When the machines are running light their counter electromotive forces are equal and are almost equivalent to the impressed voltage. When an unbalanced load occurs on one side the voltage of that side decreases so that it is less than the electromotive force of the balancer unit, and that side of the set becomes a generator. The voltage across the other unit increases so that its motor action is strengthened and it is enabled to carry the generator load of its mate. It is necessary that an appreciable shift of the neutral occur in order to bring about this change, so that compound balancers are often used in order to secure better voltage regulation.

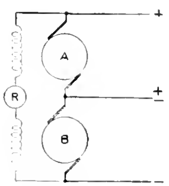


FIG. 3

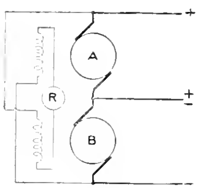


FIG. 4

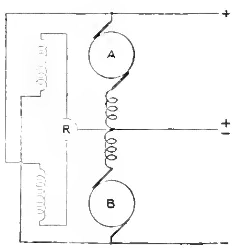


FIG. 5

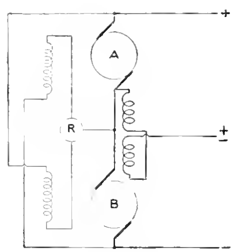


FIG. 6

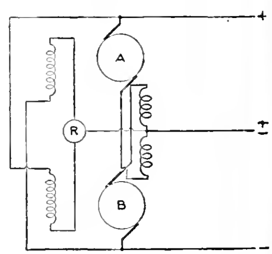


FIG. 7

FIGS. 3 TO 7. DIFFERENT BOOSTER FIELD CONNECTIONS

Shunt-wound balancers having the fields in series or parallel across the outer wires have practically constant excitation for both units. If the central point of the series-connected shunt fields be connected to the service neutral the excitation on the loaded, or generator, side is weakened and that on the motor side is strengthened. This tends to increase the motor electromotive force and reduce the generator electromotive force. The regulation with this arrangement is therefore poor. If the fields be interchanged as in Fig. 4 the generator electromotive force will be strengthened on the loaded side, tending to maintain the voltage, while the counter electromotive force of the motor is decreased, tending to speed it up, run the generator faster, increase its electromotive force and likewise maintain its voltage. Hence, this connection gives the better voltage regulation.

The action of the compound-wound balancer set (Fig. 5) differs somewhat from the shunt-wound type. Here the series field of the motor side opposes its shunt field, while the series field on the generator side assists its shunt field. Hence, the motor speed is maintained better or is caused to increase, while the generator voltage is likewise built up, tending toward good regulation. With the connection shown in Fig. 5 the series field of the motor carries more current than the series field of the generator, since the motor armature circuit carries the current to supply the losses of the set. The differential action upon the motor is, therefore, strong and the motor is likely to be unstable and to race under heavy loads.

The arrangement shown in Fig. 6 causes both series fields to carry the same unbalanced current, thereby improving stability. That of Fig. 7, in which the series fields are interchanged, places the generator series field in the motor circuit and *vice versa*. Since the motor armature current is greater than the generator armature current, the cumulative action of the generator field carrying motor current is stronger than the differential action of the motor series field carrying generator current. The excess of compounding is shifted from the motor to the generator, the rise in speed under load is decreased, there is less tendency to instability, and the voltage regulation is improved.

The units composing a balancer set act alternately as motor and generator. Therefore, the brushes must be set in a central position corresponding to no-load neutral. The neutral of a generator shifts in a direction with the rotation, while that of a motor shifts against the rotation. The brushes, therefore, cannot be located properly for both conditions. Since the motor end carries the greater load, it is well to give the brushes a slight motor lead to favor this mode of operation. It is a characteristic of the interpole motor or generator that the neutral remains fixed for all loads. Therefore, the condition of interchangeability can well be met with interpole machines and one position of the brushes will be correct for all operating conditions. Without interpoles commutation is a limiting feature and the units must be rated low to prevent sparking under load with the brushes set at a compromise position. The tendency to instability is somewhat greater for interpole sets than for those without these poles. The fact that the brushes of noninterpole machines are behind the full-load neutral as a motor, tends to hold down the load speed. In the interpole machine this effect is removed and the general tendency to maintain speed under load and to race is sometimes evidenced. The interpoles of balancer sets may require shunting with german silver, the same as is done with ordinary interpole motors.

The stability of compound-wound sets depends to some extent upon the degree of compounding. Balancers are ordinarily flat compounded or are adjusted for this degree of compounding by means of german-silver resistance shunted across their series fields. If a balancer set is connected to long feeders it may be desirable to overcompound to compensate for drop in the feeders. About 5 per cent. overcompounding is as much as can be safely provided in most sets.

Balancer sets are started with the shunt fields connected directly across the outer lines, with the center point disconnected from the neutral. The two armatures are connected in series through a starting box and are brought up to speed without load. The central point of the fields is then connected to the neutral of the set, and the voltage is adjusted for equal division. Then the neutral of the set is connected to the service neutral, and the unit is in operation.

Balancer sets may be successfully operated in parallel, but careful adjustment is necessary to secure even voltage regulation and proper load division. The units must be connected in the same manner, so that their relative speed and voltage-regulation characteristics will correspond. If the units are compound-wound one or more equalizers are necessary. If the fields are connected in series in the neutral line, as in Fig. 6, one equalizer will suffice. If they are connected as in Figs. 5 or 7 two equalizers will be required. Care must be taken to see that the equalizers connect corresponding points. The series fields should be connected on the inside next to the neutrals, as shown; if connected outside and the units were paralleled, there would be cross-currents through the equalizers into the leads to the line wires. Since the machine ammeters, fuses or circuit-breakers are connected in these leads, it is desirable that only the current for the unit protected should be able to traverse this circuit. In paralleling balancer sets the same rules hold as in paralleling any direct-current generators. If the series field circuits between the equalizers and the neutral do not have resistances inversely proportional to the machine ratings, then it is necessary to insert german-silver resistances in the series field circuit of that unit in which the resistance is proportionately low.

Adjustments

There are a number of adjustments possible upon balancer sets. Consider the case of two compound-wound interpole sets that are to be adjusted to regulate properly and to run in parallel. First, the brushes of one end of one set should be located upon neutral by running that end as a motor upon half voltage and shifting the brushes until the speed of rotation is the same in both directions running light. This procedure is then repeated for the other end of the set. Next, connect one end as a motor and the other end as a generator, separately. Connect the shunt fields as they will be connected in service. Load the generator end and note the voltage and speed regulation. If the voltage regulation is not flat (assuming that flat compounding is desired) then shunt both series fields with similar german-silver shunts and adjust the shunts until the desired result is approximately obtained. If violent sparking or racing occurs it may be necessary to shunt the interpoles also. The correct interpole shunt is best found by using a low-reading voltmeter and "exploring leads" which bridge from segment to segment of the commutator and indicate the position of no voltage between bars. When the interpole is of the correct strength the neutral will be at the same point both at no load and full load.

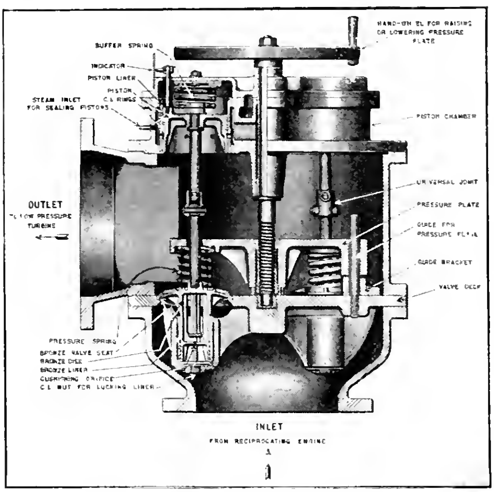
With these preliminary adjustments made, the set may be tried out as a balancer. The rheostats should be set for equal voltage division at no load. Then full unbalanced load may be thrown first on one side and then on the other and the voltage regulation noted. If it is not exactly as desired a slight adjustment of the german-silver shunts may be necessary. Possibly, one method of connection will be found to give more satisfactory results than another. Both sets having been thus adjusted and tried out singly, they may then be tried for parallel operation. If they fail to divide their load properly it may be necessary to insert german-silver resistance in the series field circuits of one of the units.

The method of protecting balancer sets depends upon the importance of uninterrupted service and the delicacy of the connected load with voltage change. Lamps are more susceptible to injury through excessive voltage than are motors. Fuses are quite frequently used in the line leads of balancer sets. A circuit-breaker in the neutral operating the circuit-breaker in the main lines by means of a trip coil will cause severance of power when excessive unbalanced load occurs, or a differential voltage relay may be used to trip the line circuit-breaker when excessive voltage inequality occurs.

The required rating of balancing equipment compared to the connected load depends largely upon local conditions. One side of a building may be dark while another side is light, or lights may be required in the central portion of a room when not necessary near the windows. Many causes contribute to unbalancing, and the amount as compared to the load is rather difficult to determine. It is desirable to maintain the unbalanced load in any system as low as possible. For this purpose throw-over switches are sometimes provided, which make it possible to transfer one or two two-wire circuits from one side of the system to the other to maintain an approximately balanced condition. Where this is not done it may be possible to connect over some of the circuits from one side of the system to the other to secure a better average balance. Sometimes, three-wire switchboards for distribution circuits are arranged to make interchange and rearrangement of circuits easy, so that balanced conditions may be maintained even though circuits are added or modified. Balancers are most frequently installed capable of handling 10 per cent. unbalanced load, that is, a load of one-tenth of the connected load all on one side of the line. Balancer units must each have a capacity equal to one-half of the rated unbalanced power, plus the losses of the set.

Cochrane Multiport Flow Valve

Among the various types of multiport valves built by the Harrison Safety Boiler Works, at 17th St. and Allegheny Ave., Philadelphia, Penn., is the multiport flow valve for use with mixed-flow turbines. Its pur-



MULTIPORT FLOW VALVE IN SECTION

pose is to close communication between the exhaust line from the engine and that stage of the turbine to which the exhaust steam is admitted, whenever the pressure in the latter falls below atmospheric.

In performing this function a vacuum is prevented in the engine exhaust pipe, the presence of which would result in the infiltration of air through leaks and past piston-rod and valve-stem packing, which would result in an overburdened condenser air pump.

In preventing the formation of a vacuum the draining of the receiver oil separator is not interfered with; this also applies to the oil separators on heaters and receivers in the engine exhaust line.

When a mixed-pressure turbine, one which receives steam at two different pressures, usually live steam and exhaust at about one or two pounds above atmosphere, is equipped with this flow valve, the exhaust steam is automatically cut off as soon as the pressure in the exhaust line approaches a predetermined maximum, say one pound above atmospheric. This action causes the flow of exhaust steam to back up and maintain a pressure in the exhaust-steam main, live steam being used by the turbine during the period the valve is closed. As soon as the exhaust-steam pressure builds up above the predetermined point the flow valves open and the live steam is cut out by the action of the governor.

The construction of the valve is shown herewith. Each valve disk is connected to and balanced by a piston of the same area. As the pressure in the turbine intermediate inlet acts on the top of the valve disk and on the under side of the balanced piston, it has no effect so long as the disk is closed. The pressure of the engine exhaust acting on the lower side of the valve disk is opposed by the pressure of the atmosphere acting on the upper side of the balanced piston. Whenever the pressure in the engine exhaust line exceeds the atmospheric a certain amount, determined by the tension of the spring pressing on the upper side of the disk, the valve opens wide, because as soon as it leaves its seat the pressure on the two sides of the balanced piston forces it out against the spring. Striking of the piston is prevented by buffer springs. When the pressure in the turbine inlet opening drops near to atmospheric pressure it, reinforced by the spring, forces the disk to its seat.

The valve thus prevents steam from flowing from the engine exhaust line to the turbine unless the absolute pressure in the former exceeds a certain minimum. As the balanced pistons are steam-sealed, no air is admitted by them.

A Cheap Covering for Steam Pipes

A nonconducting coating for low-pressure steam pipes and the like, used for the past ten years with perfect satisfaction by a Boulogne engineering firm, is described in a recent issue of the "Revue Industrielle" as being conveniently applied and cheap, while it can be prepared by any steam user. It consists of a mixture of wood sawdust with common starch, used in a state of thick paste. If the surfaces to be covered are well cleaned from all trace of grease, the adherence of the paste is perfect for either cast or wrought iron. For copper pipes there should be used a priming coat or two of potter's clay, mixed thin with water and laid on with a brush.

The sawdust is sifted to remove too large pieces, and mixed with very thin starch. A mixture of two parts of wheat starch with one part of rye starch is the best for this purpose. It is the common practice to wind string spirally round the pipes to be treated, keeping the spirals ½ in. apart to secure adhesion to the first coat, which is about ¼ in. thick. When this is set, a second and third coat are successively applied, and so on until required thickness is attained. When it is all dry, two or three coats of coal tar applied with a brush will protect it from the weather.

California's Crude-Oil Production in 1914 was 103,623,695 bbl., against 97,867,148 bbl. in 1913.

Water Power in Switzerland is conserved and utilized to such an extent that in some towns not an ounce of coal is used. Power, light and heat are furnished by water power.

Safety Valves--A Discussion

By A. B. Carhart*

SYNOPSIS—Discusses a paper read by Donald MacNicoll before the Institution of Engineers and Shipbuilders, Scotland. This paper dealt chiefly with a special safety valve in which the passage through the seat is nearly equal to the full inlet area; the main or relief valve is not spring-loaded, but is controlled by the action of a pilot valve. The reviewer shows that this, as well as other ideas, is old, and that valves so constructed have never been successful. In America since 1860 only two principles of construction have proved mechanically satisfactory. Foreign practice compared with our own.

It was before the Institution of Engineers and Shipbuilders in Scotland that Hazleton R. Robson presented his paper in 1873 demonstrating the advantage of springs instead of dead weights and levers for loading safety valves. This was several years after spring-loaded pop safety valves had been introduced into this country.

Recently Donald MacNicoll, of Cockburns, Limited, Glasgow, read a paper on safety-valve design before that society, the paper dealing chiefly with tests of some special "full-bore" safety valves recently applied to boilers of destroyers in the British Navy. The interesting feature in these valves is that the passage through the seat is practically equal to the full area of the inlet. But the main relief valve is not spring-loaded and proportioned to give automatic opening and closing, to make the amount of blow-down in pressure adjustable, but is in effect simply an adaption of the "compound" whistle valve commonly used in this country, having a steam piston whose operation is controlled by the action of an auxiliary pilot valve. This idea is not new, for other valves operating upon the same principle have been patented in Great Britain and in this country; and as long ago as 1871 Thomas Adams read a paper before the same society, in Glasgow, describing a relay type of safety valve patented by him, in which the opening of the main relief valve was controlled in similar manner by the action of a much smaller valve. But none of these valves has ever been commercially successful, and Mr. MacNicoll's paper indicates that mechanical difficulties have been encountered in the latest type, and that much must still be accomplished before it is as satisfactory as the safety valves commonly used in this country. For example, he says: "All the valves lift at about 7 lb. above the working pressure, drop or close on their seats at the working pressure, and are absolutely tight at not more than 7 lb. below the latter."

Mr. MacNicoll's paper is interesting, but much of the work he refers to has already been done in this country, and much, if not all, that he describes as the latest endeavors in such experimental work in Great Britain, is shown in various American patents issued twenty-five to forty years ago.

The safety valves commonly used in Great Britain are not of the type so familiar here. Instead of having the "pop" feature, most of them are valves without any expansion chamber at the lip to give full initial lift, and which depend upon long and flexible springs to permit sufficient opening at the seat. But although many in this country know that the safety valves used abroad do not afford as much relief in steam discharge as pop safety valves, it is interesting to find the corroboration of this in Mr. MacNicoll's paper. Of safety valves commonly made there, he says:

> In connection with the Board of Trade type of valve, the accumulation allowance or the amount of excess pressure over the working pressure, when all stop valves and feed-check valves are shut and the specified amount of coal being burnt, must not exceed 1 per cent. of the working pressure. The Admiralty allowance is 7 per cent., but with the feed maintained; this latter, of course, is essential for water-tube boilers. In most cases, with Board of Trade valves it has been found that when the working pressure exceeds 210 lb. by gage, this allowance is exceeded.

Mr. MacNicoll says that a possible explanation of this undue rise in pressure, indicating insufficient valve-discharge capacity, lies in an insufficient escape-pipe area, resulting in a throttling of the escaping steam, causing back pressure on the valves and preventing them from lifting properly.

> This pressure has gone up as high as 40 lb., whereas it should never be more than about 15. . . . . It has been suggested that in certain cases an accumulation test has been stopped, owing to the accumulation having got considerably beyond the allowance, and was still rising, the surveyor knowing at the same time that he was not justified in condemning the valves, as the area was correct and compression of spring in order, according to the Board of Trade formula. It would appear in cases of this sort that the valve had not enough lifting effort.

Concerning the lifts of such valves, he says:

> It must be remembered, however, that American safety valves have very different fittings from those manufactured in this country. The rigid type of spring adopted in the former giving less than 1/8 the diameter of the valve for initial compression, necessitates a carefully designed seat and plate on the lid to lift the valve sufficiently. . . . . The short rigid spring is noticeable when compared with the present British Board of Trade type. . . . . Since the introduction of the spring-loaded Board of Trade type of valve, the design has altered but little. . . . . It should be set to lift at from 5 to 7 lb. above the working pressure, and when properly constructed should drop on its seat at about the working pressure. The compression of the spring at the blowoff pressure should be 1/4 the diameter of the valve.

He describes also the Admiralty type of spring-loaded safety valve, in which "the specified initial compression of the springs is equal to the diameter of the valve, or four times the elasticity of the Board of Trade springs." Even the great length of the springs, 11½ or 13 coils, or more, is not sufficient to insure proper lifting of the valves to afford free steam discharge, as is further evidenced by Mr. MacNicoll's quotation from a report of the trial, made some five or six years ago, of an experimental type of valve:

> The ordinary spring-loaded safety valve is usually big enough to take away all the steam that an ordinary boiler can generate under ordinary firing conditions. Certain peculiarities are inherent, but seem to have become accepted with resignation by engineers. For instance, the lift is usually inadequate, owing to pressure accumulating above the valves, and acting downward on the larger area provided by the lip. . . . . When the valves lift, the rush of steam past the lip prevents the valve closing until the pressure in the boiler has fallen considerably below the working pressure. This is known as "drop," and may amount to as much as 10 per cent. of the working pressure. It is usually looked upon as inevitable, but is a serious matter on a full-power trial where the loss

*Superintendent, Crosby Steam Gage & Valve Co.

of water is measured and where it is important to maintain full boiler pressure over a long period, hence the practice of having a man told off to watch if any valve lifts, and to at once tap it down again on to its seat.

Concerning the lift of safety valves, he comments upon the experiments made a few years ago, and says:

Although the balance-disk valve was not considered satisfactory, it was agreed that a valve giving a greater lift than the ordinary type was desirable. The ordinary type of valve lifts about $\frac{1}{24}$ of its diameter, while the Gibson valve lifted $\frac{1}{16}$.

Referring to the experiments made in 1874, he says:

It is suggested that with a specially designed Cockburn valve it reached the full amount—namely, ¼ of the diameter—but this is not likely, and certainly a rule proposed by the committee allowed for a lift of only $^1/_{36}$ of the diameter.

This would seem to indicate that foreign safety valves, in spite of the long springs, do not have the excessive lifts with which they are sometimes credited in discussions of the subject. The duty under our present tariff is not high enough to prevent the importation of safety valves from abroad if they were desired. Some manufacturers in this country are often called upon to duplicate such valves for marine boilers in special cases, but even this intimate knowledge of their construction has not led to their general introduction here. One statement made by Mr. MacNicoll concerning some of the valves tested, using large springs made according to the Admiralty rule, indicates that the long springs have disadvantages that might develop into exaggerated difficulties under American conditions of service:

In torpedo-boat-destroyer work also, the large springs had been found to be a source of trouble; excessive vibration keeping the springs continually on the dance, and serious leakage consequently ensuing.

Mr. MacNicoll describes the experiments of J. H. Gibson, of the firm of builders of the British torpedo boat destroyer "Cossack," which was one of the first vessels burning oil fuel in which serious difficulty was experienced with the ordinary Admiralty safety valves:

During the accumulation trial the steam pressure rose to a dangerous extent with the pointer of the gage going up rapidly. To prevent an accident the easing gear was applied. It was observed that it required only a very small additional lift to the valves, somewhere about $^1/_{64}$ in., to keep the accumulation within the specified amount. . . . . . While the new valves were being manufactured, he carried out an experiment on one of the original valves. A small steam cylinder fitted with a piston was attached to the boiler shell in the vicinity of the safety valve. The piston was attached to the easing gear in such a manner that on the piston moving outward the valves were eased. The bottom of the cylinder was connected with the waste-steam space of the safety valve. The effect was that the excessive pressure in the waste-steam space assisted the valves to lift instead of preventing them from doing so.

This experimental valve was described, at the time, in *Engineering* (London), Feb. 26, 1909, and mentioned by the writer in an article in POWER, Mar. 23, 1909. The comment is made that "the trials were most satisfactory," but subsequent events cast doubt upon this conclusion. It is apparent that only one such valve was ever made; and the idea of utilizing the excessive back-pressure in operating a lever to overcome its harmful effects seems too much like lifting one's self by the boot-straps. In the torpedo boat destroyer "Swift," constructed later by the same firm, each safety valve, "instead of having an external cylinder as previously mentioned, was fitted with a balancing piston, or disk, which neutralized the effect of back-pressure in the valve casing." This device was sufficient to overcome the difficulty with the safety valves, as far as the accumulation allowance under test was concerned.

But this idea also, of a larger disk fixed to the valve spindle, is not new, for it is shown in many of the older patents. A somewhat similar scheme for using the back-pressure to give extra lift to the valve was an important feature in the old "Crosby-Meady" muffled locomotive pop valve of 1885, that showed lift of ¼ in. This had a considerable sale thirty years ago. In justification of such a device, the report upon the tests of these experimental valves says:

To obviate the objectionable action of this pressure [the back pressure in the valve casing] and, if possible, to make it perform useful work is the object of this invention. By making the balancing disk equal in effective area to the valve, the effect of the fluctuating pressure in the valve box is eliminated, and the valve lifts gradually and quietly to the full amount permitted by the compression of the spring, and the allowable accumulation. . . . . The removal of the lips from the valve and seat steadies the action of the valve, and prevents "beating" or "chattering," thus increasing its life or period of steam-tightness.

"*Gradually and quietly*" in the original report emphasize the desirability, sometimes too little appreciated, of the practical advantages of smooth and quiet operation of a boiler safety valve, as compared with the sudden and violent explosiveness that sometimes results from an effort to obtain an excessive rate of discharge or an instantaneous relief. However, it is evident that the desired results were not fully realized, for Mr. MacNicoll says:

Subsequently, Messrs. Cockburns made valves of this type, but it is regretted that while amply meeting with accumulation conditions, the question of when the valves commenced to lift and when they shut off tight was a most vexed one. With the ordinary type of valve the lift is definite—a distinct "pop" is heard, although simmering may have taken place for some time previously. With the balance-disk type the first slight feather at the waste-steam pipe was taken as the commencement of lift, this gradually increasing till the valves were blowing full; the range of pressure every time the valves lifted was about 30 lb. per square inch. Similarly, on the valves closing again the range was 35 or 40 lb. per square inch. These valves were refitted repeatedly, with no betterment.

Mr. MacNicoll describes the difficulty they had with continued leakage at the valve seat (attributed to distortion of the seats of the valves, which were 3½-in. size) and mentions the improvement in the behavior of the valves after they were fitted with a different type of disk, but makes the significant statement:

After this they never gave satisfaction, and about 18 months thereafter were replaced. Subsequently, it was found that this type of valve had been used in the United States for a considerable time.

The next form of experimental valve tried was upon the same principle, but had a much larger piston fitted above the valve disk, so that back pressure in the body would force the disk further from its seat. It does not seem logical to have developed this idea so far; for the real purpose of any safety valve employed should have been to discharge the escaping steam, for the relief of the boiler, rather than to throttle the discharge pipe to gain more lifting power inside the valve body. For of what use is it to gain greater lift and larger opening at the valve seat if free discharge of the steam from the valve casing is not permitted? This valve appears to have been inoperative except under special conditions. To again quote Mr. MacNicoll:

The piston was made considerably larger than the valve, and a stop valve was fitted to the outlet as shown, so as to maintain any desired pressure in the waste-steam space. This valve could be made to give a lift of ¼ of its diameter under favorable conditions, but was found to be somewhat erratic in its action, and the slightest increase to the lift on the stop valve from that which allowed of full lift to occur in the safety valve prevented the latter from lifting more than a very small amount. The drop also was very inconstant —generally the valve was considered unsatisfactory.

As an alternative device, intended as an improvement upon the experiments described, a compound valve was devised, in which the opening of a small spring-loaded pilot valve allowed the steam behind a piston of larger area to force open a main relief valve against the boiler pressure.

Such valves are interesting in principle, but have been described in early U. S. patents; for example, in the patents to Shepard in 1873, to Anderson in 1877, and to Scovell in 1879, as well as in that to Collier in 1882. Many variations in the mechanical embodiment of the same idea have been tried, but have never been able to displace the familiar automatic safety valve of the "pop" type. In the discussion of Mr. MacNicoll's paper, R. A. McLaren stated that he had designed a valve on much the same principle between twenty and twenty-five years ago.

George W. Richardson, the inventor of one of the early successful American safety valves, was granted his first patent in 1866, and this was followed by another in 1869, the papers of which describe the adjustable ring for regulating the amount of blowdown in boiler pressure. Among the numerous safety valves shown in United States patents since 1860, only two fundamental principles of construction have proven mechanically satisfactory. These are Richardson's idea of an overhanging lip and stricture ring, forming an adjustable "huddling chamber" surrounding the valve seat, and Crosby's opposite plan of using a flat, double seat and controlling the blow-down by regulation of the small part of the discharge that is bypassed through a central chamber beneath the disk, instead of at the valve seat. All the later commercially successful improvements have been based upon the ideas of one or the other of these two pioneers.

One difficulty met with in the designing of any spring-loaded pop safety valve that is to be self-regulating and automatic in operation, is the limitation upon the amount of spring compression and lift of the valve that can be easily attained without sacrifice of some of the desirable characteristics of such valves. Therefore, the devising of other forms of boiler relief valves has been a favorite field for inventors' schemes. Even during the discussion of Mr. Robson's original paper before the Institution in Glasgow in 1873, David Rowan remarked: "When we have a safety valve which will lift one-fourth of its diameter, or to give an area equal to the diameter of the valve, then the question will be put on a scientific basis." This underlying idea has persisted ever since, and is rediscovered in turn by each one who gives original thought to the subject. This is doubtless the reason why so many have experimented with various forms of balanced-piston and relay valves, which apparently would give "full opening" for boiler relief.

A reliable automatic safety valve must do more than merely discharge steam. In fact, the opening of a relief valve to give "full discharge" is one of the simplest details in the problem, and easiest of solution. Even Mr. Rowan, back in 1873, said that it "could easily be done." The greatest difficulty arises in getting the valve closed again. The wide range of blow-down commonly accepted in foreign practice, or in the operation of valves on marine boilers, would not be countenanced by operating engineers in this country, after their experience with modern pop safety valves.

Comments appearing incidentally in Mr. MacNicoll's paper are especially interesting as indicating that some of the safety-valve specifications appearing in the new A. S. M. E. Code are wise and proper. For example, he emphasizes the lesson drawn from some of the safety-valve experiments, that discharge piping of ample size must be provided for carrying away the exhaust steam from the safety valve. In connection with the subject of springs for safety valves he says:

> There appears to be a broad rule, however, for determining a safe spring—that is, one which will remain for any length of time under a load with the coils almost touching, maintain this compression, and resume its free length when the load is removed.

The recently approved specifications of the A. S. M. E. on this subject are intended to accomplish this to insure that springs used in safety valves shall not under any circumstances take any permanent set.

After describing in detail the construction and method of operation of the piston type of valves in the latest experiments, Mr. MacNicoll comments:

> If they are placed near the top of the boiler and have easy leads in the waste-steam pipe, no vibration or movement will take place. If, however, they are fitted with internal pipes there is a tendency to vibration; apart from this, internal pipes are most dangerous when fitted to safety valves, and serve no useful purpose.

This seems to be further confirmation of the wisdom of the provision in the A. S. M. E. Code that safety valves shall be connected directly to the shell of the boiler.

There has been some discussion concerning the most practicable method of calculating the total boiler evaporation for which safety valves should be provided, and upon this point one comment of Mr. MacNicoll's is pertinent:

> With the advent of oil fuel in the Navy, the size of safety valves based on a formula taking coal as a factor proved altogether inadequate. It appears somewhat singular that the formulas for arriving at the size of safety valves, in the case of the Board of Trade rule, should be derived from area of fire grate and steam pressure, and in connection with the Admiralty, from heating surface and steam pressure. One would have thought the factors necessarily presenting themselves would have been evaporation and steam pressure. . . . .
>
> Turning to the rule formulated by the Board of Trade, it appears somewhat strange that they should have decided on a rule which gives a "disk area" and not a "clear area" for the escape of steam. . . . . As already stated, it now appears that it would have been better had the Board of Trade rule settled the actual area for discharge. During the experiments by the committee it was found that the lift was variable.

The Horsepower of a Cannon

A matter of speculation likely to interest engineers is the enormous energy or horsepower developed in the breech of a big modern cannon discharging a projectile weighing, say 1850 lb., at a velocity of 2000 ft. per sec., when

$W = 1850$ lb.;
$V = 2000$ ft.;
$g = 32.16$.

The formula $E = \frac{WV^2}{2g}$

gives 110,000,000 ft.-lb.

This amount of work must be accomplished during the projectile's travel in the gun, probably not over $^1/_{100}$ of a second. Therefore,

$$\frac{110,000,000 \times 100}{550} = 20,000,000\ hp.$$

or in another way, the vertical distance a body would have to fall to attain a velocity of 2000 ft. per sec. at a uniform rate of acceleration due to gravity would be about 60,000 ft. A projectile weighing 1850 lb., falling this distance would generate

$$1850 \times 60{,}000 = 111{,}000{,}000 \textit{ ft.-lb. of energy.}$$

The same amount of energy would be required to produce the same velocity at the muzzle of a cannon and represent in horsepower

$$111{,}000{,}000 \div 550 = 200{,}000+ \textit{ hp.}$$

if done in one second; but the actual time is probably about as the length of the gun is to the velocity, or 20 to 2000, or $^1/_{100}$ of a second. The energy exerted for the shorter period must be 100 times greater, or equal to 20,000,000 hp.

Foster Automatic Feed-Water Regulator

The Foster automatic feed-water regulator is designed to maintain water at the predetermined height. Normally, the water in the boiler or water column seals the end of the pipe leading to the top of the expansion tube, so that steam is excluded therefrom and the tube is cool or contracted. In this condition of the expansion tube the long arm of the bell-crank lever *A*, Fig. 1, is free to swing outward and allows the weight to depress the arm of the lower bell crank *B*, so as to slide the valve *C* downward into a closed position, cutting off and preventing water from entering the boiler through the feed line.

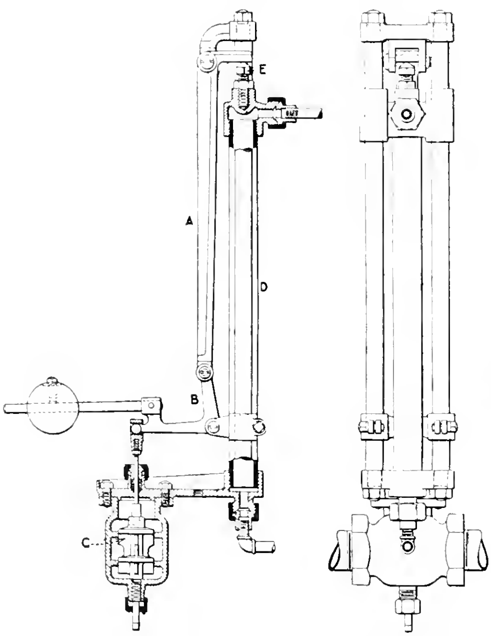


Fig. 1. Details of the Foster Feed-Water Regulator

When the water recedes below the predetermined level, it uncovers the opening in the pipe leading from the water column to the top of the expansion tube and permits steam to enter it. This heats and expands tube *D*, carrying the adjusting screw *E*, which can be set for any desired variation, upward against the short arm of the bell-crank lever *A*, thus swinging the long arm of the latter inward or toward the expansion tube. This carries the lower bell-crank lever *B* and raises the weight, drawing the valve *C* upward, opening the main feed valve, and permitting water to flow through the feed pipe into the boiler. The flow continues until steam is again cut off from the expansion tube *D*, allowing the latter to contract sufficiently to close the valve *C*. Fig. 2 shows the regulator and pump connections. This regulator is manufactured by the Foster Engineering Co., 119 Monroe St., Newark, N. J.

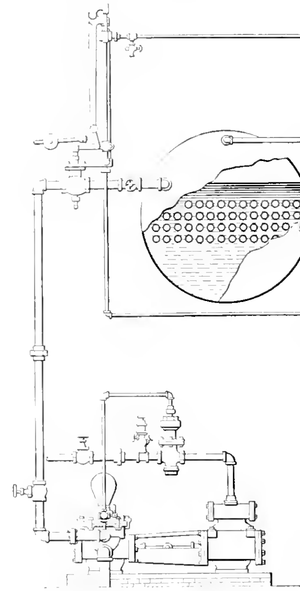


Fig. 2. Regulator and Connections

Rules for Properties of Copper and Brass Pipes

The British Board of Trade rule for the thickness of brazed copper steam pipes is

$$T = \frac{D \times P}{6000} - \frac{1}{16}$$

in which

T = Thickness of plate in fractions of an inch;
D = Diameter of pipe in inches;
P = Working pressure in pounds per square inch.

For working pressure of brazed copper steam pipes,

$$P = \frac{6000 \times (T + \frac{1}{16})}{D}$$

To find the weight of copper pipes,

$$W = 3.03\ (D^2 - d^2);\ \text{or}\ 3.03\ (D + d) \times (D - d)$$

in which

W = Weight per lineal foot of pipe in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
3.03 = A constant.

To find the weight of brass pipes per lineal foot,

$$W = 2.82\ (D^2 - d^2);\ \text{or}\ 2.82\ (D + d) \times (D - d)$$

in which

W = Weight of pipe per lineal foot in pounds;
D = External diameter of pipe in inches;
d = Internal diameter of pipe in inches;
2.82 = A constant.

Editorials

License Laws in Massachusetts

There have been ructions in the good old Commonwealth of Massachusetts for the past few weeks. A powerfully organized attack has been made upon the existing law by the employers, who complain that it contains, in addition to its provisions for safety, features that impose unnecessary hardships upon the employees and useless burden upon the manufacturers; that it recognizes no difference in the risk of operation between steam engines and steam boilers; that it fails to limit the scope of examinations and permits the requirement of knowledge of the principles of design in the examination of applicants for license to operate, of a knowledge of the principles of boiler design in an examination for a permit to operate engines, and permits the examiner to require involved mathematical calculation, thereby denying employment to competent men.

There have been, for a long time, evidences of friction between the employing and the laboring interests, over the interpretation and administration of the law. Shall a single licensed man in responsible charge suffice for a plant, or shall everybody, down to the coalpasser, be required to have a license?

Shall the examiner simply satisfy himself that a man knows enough to keep water in the boiler and the safety valve clear, or shall he assure himself, broadly, of a man's ability as an engineer and of his general understanding of the principles of and of his familiarity with, the apparatus involved, in the processes of the oversight of which he seeks responsible charge?

Shall an inspector fearlessly and impartially enforce the provisions of the law and the Code, or must he handle friends of the appointing powers with particular consideration to hold his job?

Stories are told of an inspector who made seventy-three arrests and got seventy-two convictions, whose pernicious activity was checked by laying him off for three months "for using language unbecoming an official." On the other hand, it is maintained that the inspectors appointed by the District Police do not all know too much about boilers themselves.

The manufacturers, therefore, had a bill, known as House Bill No. 1111, introduced, which provided that with every licensed person employed there may be one unlicensed person employed, who, in the presence and under the personal direction of the licensed person, might operate steam boilers and their appurtenances; defined what was meant by "control," "operation," "have charge of," etc., as used in signifying where licensed men were required, etc. The bill also required a different examination and license for a man who was to have charge of engines than for one who was to have charge of boilers, and provided a practical examination for both, with the privilege of having present an observer who might take notes.

This bill met with strenuous opposition from the engineers, and on Mar. 22 the Governor addressed a message to the Legislature, in the course of which he said:

> As you are doubtless aware, there has been for some years a serious controversy between the representatives of organized labor and the representatives of the manufacturing interests, in regard to some of the provisions of the existing law relative to engineers' and firemen's licenses and in regard to the enforcement of law by the Boiler Inspection Department of the District Police. I am informed that after repeated conferences and long discussions these differences have now been amicably adjusted and an agreement reached whereby the opposition of organized labor to House Bill No. 1111, amending the law regarding engineers' and firemen's licenses, is withdrawn and the support of the manufacturers to the bill herewith transmitted is accorded.

The bill "herewith transmitted" takes the inspection of boilers and the examination of engineers entirely out of the hands of the District Police and establishes a Bureau of Steam Engineering and Inspection to take care of it. Bill No. 1111 was withdrawn by mutual consent of a committee composed of engineers and manufacturers, and in its place another bill has been drawn up, amending the present law so as to overcome the objections of the manufacturers without prejudice to the engineer.

New Methods of Producing Gasoline

Widespread interest has been created within the past few weeks by reports in the daily press of discoveries calculated to greatly increase the supply of gasoline, besides making available benzol and toluol, which heretofore have been produced from coal tar. The toluol is an important ingredient in modern high explosives. First came the announcement of Dr. Snelling's process, to be followed closely by that of Dr. Rittman, and finally the information that Edison had started a plant for the production of benzol and a number of residual products, ordinarily imported from Germany but now cut off as a result of the war.

In Dr. Snelling's process synthetic crude oil is produced from hydrocarbons such as kerosene, fuel oil, lubricating oil and paraffin (themselves originally obtained from crude oil), by heating in an air-tight vessel or "bomb" until about eight hundred pounds pressure is reached, the substance occupying only about three-elevenths the volume of the bomb. The action appears to consist of a rearrangement of the atoms, and upon cooling, crude oil is obtained. This synthetie crude oil, when subjected to fractional distillation, will give off approximately fifteen per cent. gasoline. Thus the process is cyclic and through repetition can be made to yield a large proportion of gasoline.

Dr. Rittman's process, it appears, depends upon "cracking," but the petroleum is first vaporized and then subjected to the necessary pressures and temperatures for the production of gasoline, or further, benzol and toluol. Fifty to seventy-five per cent. of gasoline is said to be attainable, besides the other products.

The Edison process has not been made public.

Both Dr. Snelling's and Dr. Rittman's processes are still in the laboratory stage and it would be useless to make any predictions as to their probable effect on the fuel and byproduct situation in this country. However, lest some be misled into the belief that the relatively large percentage of gasoline thus obtainable will greatly affect the price of that fuel, it may be pointed out that in the Burton process, controlled and employed by the Standard Oil Co., about seventy per cent. of the crude may be converted into gasoline. It is understood, however, that ordinarily not over forty to forty-five per cent. is extracted, not because of any mechanical or chemical difficulties, but solely for commercial reasons. That is, if the market demands are such as to make it more profitable to sell forty per cent. of the heat units of the crude in the form of gasoline, thirty per cent. as kerosene, twenty per cent. as fuel oil, etc., the process will be adapted to meet these conditions. If the market demands for these products are in some other ratio, the condition will be met. In other words, the Burton process is used as a "balance wheel" to suit the market and effect the most profitable production.

Now, if the new processes are developed commercially will they not to a large extent serve a similar purpose? As an economic problem it is not reasonable to suppose that the production of gasoline will be increased to such an extent as to greatly lower its price to the consumer if the demand for the heavier oils for use in the oil engine is such as to make an increased production profitable; similarly with the other distillates.

Perhaps the most important feature of Dr. Rittman's discovery, as concerns the public, lies in the fact that it is government property and as such will be free to all. Thus the independent refiners may take advantage of it and will be able to compete with the Standard. While they will also be governed largely by market demands, they may serve as a check against any artificial boosting of prices or demands; provided, of course, their supply is unhampered. Again, the production of the tolnol and the other residuals, while possibly unable to compete with the imported coal-tar products after normal conditions have been resumed, will nevertheless serve as an important asset in time of necessity.

Listing Motor Data

Inadequate records of local motor installations are a common source of delay in power plants in which the operating engineer has jurisdiction over electrical as well as steam equipment. Trusting to memory as to the size and speed of individual motors may be all right when only a few are in service, but in a large plant it pays to keep an uptodate card or loose-leaf record showing in detail exactly what each motor is doing. The necessary data include the horsepower rating of each motor, its pulley diameter and face, the speed at normal rating, and the pulley and speed particulars of the main shaft of machinery or grouped tools driven, pinion and gear sizes, and the number, make and capacity of the machines run by each motor. In a representative mill installation where this information is maintained by the plant engineer each motor is provided with an index card bearing the above particulars; and in addition, space is left for recording test data, so that at any time the plant manager can be informed accurately of the load on any motor, just how many machines it is driving, and how many it should drive if loaded to its full rating. With modern induction motors this plant runs its machine drives in many cases on the basis of loading individual motors from fifteen to twenty-five per cent. beyond their nameplate rating. In case of any desired change in tool arrangement, alteration of stock or other modification of the installation, the engineer's record shows at a glance just what the condition of each drive was at the last test and indicates the course to be followed with reference to the addition of machines to any group or the substitution of a motor of different size to meet the proposed load conditions. Every lineshaft in the mill is identified by a letter corresponding to the card record of the motors, and the amount of time saved in making estimates of local power requirements is surprising, compared with the ordinary method of making a new power survey every time any question of importance arises in connection with the capacity of the motors.

Specifications

Judging from the evidence, the average writer of specifications has little knowledge of piping work, but a great desire to catch the unwily bidder. Many specifications are voluminous, and many and devious are the methods used to avoid telling the bidder all that he should know in order that his bid may be intelligent and his chance of loss minimized. At the other extreme are the specifications that are manifestly lacking in detail.

Specifications of either kind are neither creditable to the architect or engineer who wrote them, nor valuable to the owner, nor are they in the interest of clean competition. Rather do they work against the honest bidder, who justly refuses to spend his time doing the architect's work, knowing from experience that others competing with him, with less respect for their trade, are only too willing to propose a system that will just pass. The honest bidder and the owner are the injured parties, and the less conscientious bidder has a field for his activities. It is true that piping work must conform to certain regulations, but the opportunity to skimp the job is ever present, and in heating work the chances are still greater and the use of inferior material more frequent.

After the contract is secured, there is invariably constant wrangling over the interpretation, both parties putting forth good reasons for their contradictory renderings, the owner trying to get the best service at the least expense and the contractor striving his utmost to make the contract call for the least material and labor. There is also room for argument regarding the acceptance of material supposedly "equal" to that called for, the final judgment being usually left to the representative of the architect, whose experience in such matters is by no means commensurate with the dignity of the position he is to fill.

Why should specifications not be written with precision, so as to be deserving of respect, inspiring the desire for clean competition, with scant opportunity for work that will barely pass?

The advocates of the Water Power Trust claim that it is better that the water powers should be developed, even at the expense of turning them over to private capital for this purpose, than that they should lie dormant and the fast diminishing coal supply be burned up to produce the power which they might generate. It is probably better that anthracite coal should be mined and supplied to the public even at eight dollars a ton than that it should lie in the ground, but it would be a whole lot better to have it mined by the people themselves and made available at half the cost. Don't let the white coal get where the black is.

Correspondence

Two Ways of Going to Work

It takes me from twenty to twenty-five minutes to get to my work. One morning, across from me in the car was a fellow who was very much engrossed in reading some article in POWER. Next to him was another man sound asleep, with his feet stuck out in the aisle. The former seemed to be enlightened on some subject which had puzzled him. The other, dead to the world, was keeping passengers busy stepping over his feet.

At the shop I again noticed the same two men. The "dead one" was at the drinking tank, complaining to a fellow workman about the small pay he was getting; the other was busily engaged with his work. I learned that they were getting the same pay, although the dead one had worked twice as long at the place. I went my way, satisfied that I had a mirror worth holding up to my fellow readers.

MILTON W. ELMENDORF.

Wilkinsburg, Penn.

[The cartoon in this issue was drawn from a sketch accompanying the above letter.—EDITOR.]

Auxiliary Exhaust Valves on Uniflow Engines

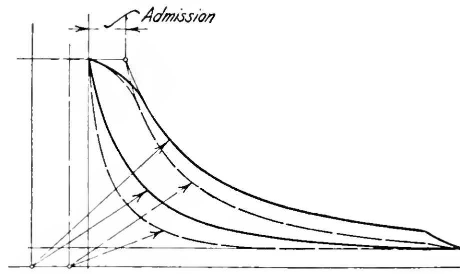
I have read with great interest the letter in the Mar. 30 issue of POWER, criticizing Professor Stumpf's article on the uniflow engine. In view of the distance of Professor Stumpf and the delay in the mails due to the war, I take the liberty of replying to this article. I was associated with Professor Stumpf during the introduction of the uniflow engine in Germany and am familiar with his work.

The question at issue seems to be whether or not uniflow engines should be fitted with auxiliary exhaust valves. There can be no question that condensing engines are better without these valves. They not only add to the mechanism and complication of the machine, but they decrease the thermal efficiency even if locked closed and absolutely tight, as they must have some clearance; and as the steam remaining in this clearance is not raised in pressure by compression, it causes a much greater loss than the same amount of clearance at the end of the stroke would.

It is true that when uniflow engines were first brought out several cylinders were wrecked, but these were cracked by initial strains due to improper design and not by high compression. There have been two accidents in this country that were probably due to excessive compression caused by loss of vacuum, but these engines had Corliss valves which could not lift sufficiently to relieve the pressure, and they broke at the cylinder heads and not through the exhaust ports.

The fact that there is in successful operation in Europe more than 600,000 hp. of condensing uniflow engines without auxiliary exhaust valves and that engine builders continue to leave them off, is proof that they are not required for safety. Since the first engines were built there has not been a single accident of the kind mentioned above with an engine built from Professor Stumpf's design.

The question of noncondensing engines presents a different problem. The uniflow engine requires large clearance and consequent loss (Fig. 8 of the article in question is incorrect and misleading, as may be seen from the accompanying cut, in which both cards have the same admission; the loss is by no means the shaded area *B*, as the description of Fig. 8 states), but this loss decreases with high steam pressures and low back pressures. Auxiliary exhaust valves also cause additional losses due to partially defeating the uniflow advantage and the additional clearance as mentioned above. These losses increase with high steam pressures and low back pressures. We therefore have two engines—one in which



AUXILIARY EXHAUST ON UNIFLOW ENGINES

the efficiency increases as the steam pressure increases and the back pressure decreases, and the other in which the efficiency decreases as the steam pressure increases and the back pressure decreases. The engine with auxiliary exhaust valves must be more efficient at low steam pressures and high back pressures, and the engine without auxiliary valves must be more efficient at high steam pressures and low back pressures.

Where these curves of efficiency cross cannot be accurately determined until there are more data of authentic trials of these types available than at present, but from the data at hand it is probably somewhere between steam pressures of 120 and 150 lb. at atmospheric exhaust.

It must not be understood that it is necessary only to build an engine on the uniflow principle to make it economical. There is just as much difference between uniflow engines as between those of any other type, and the engine must be properly designed to get good results.

I am not surprised that "One American builder, after having built and thoroughly tested a noncondensing uniflow engine having no auxiliary exhaust valves, now refuses to bid on the uniflow engine for noncondensing service," if he cannot build an engine which will do better than 24¼ lb. of steam per hp.-hr. If this engine had been properly designed for the work, it would have done at least 25 per cent. better.

One test does not prove anything, especially if the results are negative, and it is of no value whatever unless all conditions are noted.

There have been many trials by disinterested experts, and records as low as 14 lb. of steam per i.hp.-hr. (noncondensing) have been made with uniflow engines without auxiliary valves, and these records have never been approached with engines fitted with auxiliary exhaust valves.

W. TURNWALD.

Syracuse, N. Y.

Making a Spray Cooling Pond

High efficiency, low first cost, durability and attractiveness are the chief merits claimed for the cooling pond described herewith and illustrated in Figs. 1 and 2. The jets of spraying water have all the charm of a collection of fountains—a sight incomparable with the old-style towers or the newer masonry towers. The device described belongs to the Rea Patterson Milling Co., of Coffeyville, Kan.

Besides the pleasing appearance, the next important feature of this device is its durability. Being all iron and concrete, there is practically no wear and nothing to require attention or get out of order, and there is no danger from wind storms. Fifteen pounds' pressure is all that is required to operate the spray. The loss by evaporation is about the same as in other spray cooling devices.

This cooler handles 1500 gal. per min., reducing the water to normal temperature. This is regulated by the pressure, and thereby the height to which the spray rises; the humidity of the atmosphere is also a governing factor. The cost of the plant was as follows (estimated): Ground, $400; excavating (800 yd.), $250; concrete and labor, $1250; iron pipes and nozzles, $550; total, $2450.

The cost of a cooling tower with fan to perform the same amount of work was estimated at $5000. The brass

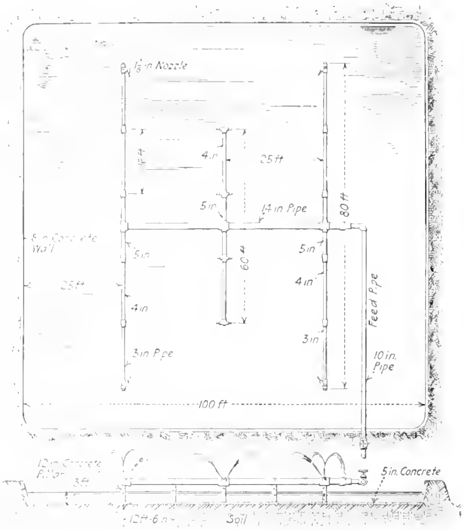


FIG. 2. PLAN AND ELEVATION OF COOLING POND

nozzles are of special make and cost $500 for the twenty used. The bottom of the pond is lined with five inches of concrete and the depth of water is about three feet. The concrete columns supporting the pipes are 12 in. square in cross-section, and they are spaced 12 ft. 6

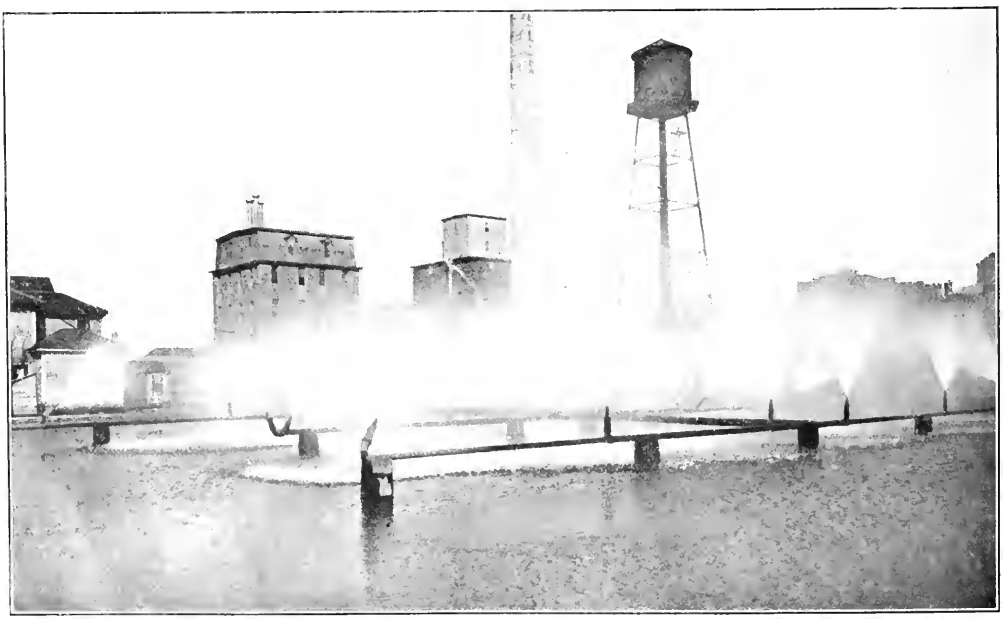


FIG. 1. COOLING POND DESIGNED AND INSTALLED BY THE PLANT'S OPERATING ENGINEER

in. apart on straight runs. The cooling pond has been in service about a year.

J. I. Blair.

Coffeyville, Kan.

Plate Valve for High-Speed Air Compressors

I have read, with much interest, Mr. MacFadden's article on "Plate Valves for High-Speed Air Compressors," appearing in the Mar. 16 issue, and I wish especially to refer to the statement that it requires less power to operate these valves than it does other types of valves.

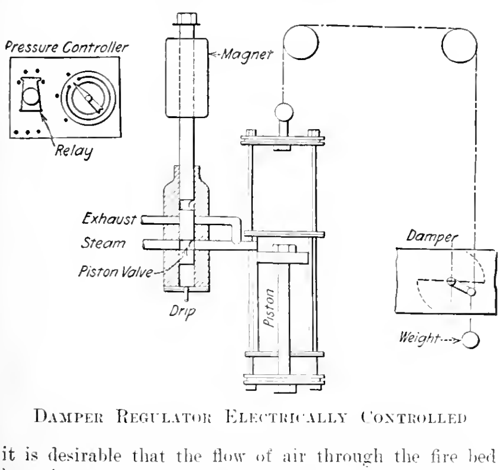
I have heard several discussions on the actual pressure required to open inlet and discharge plate valves and there seems to be a wide difference of opinion as to the actual pressure required. Many of us are interested in this subject and would be interested to know if there are any actual data by which we can determine the pressure required to open these valves. I presume that this, to a certain extent, depends upon the design of the valve, but authentic published data will be highly interesting.

J. I. Blount.

Birmingham, Ala.

Electrically Controlled Damper Regulator

The function of a damper regulator is to check the draft when the boiler pressure reaches a predetermined limit. Having determined the amount of air required to burn a certain kind of coal and the quantity that it is desired to burn per square foot of grate area per hour,



Damper Regulator Electrically Controlled

it is desirable that the flow of air through the fire bed be maintained as nearly constant as possible. The damper should remain shut only long enough to check the rise in pressure and reopen when the pressure has decreased one pound below the predetermined limit. If it requires 0.68 in. of draft to burn No. 1 buckwheat coal at 20 lb. per sq.ft. of grate area per hour, and the damper is adjusted to control the air supply to that amount, then the regulator should open and close between the limits of 1-lb. rise and fall in steam pressure, and the fire will be allowed to cool but little before it is burning again at the full intensity. It will be found that under that close regulation with natural draft a much more uniform and higher average CO_2 can be maintained and the efficiency of the boilers increased, with the resulting saving in coal. The illustration shows an electrically controlled damper regulator that I designed to meet conditions where the closest possible regulation is expected. The results with natural draft are nearly equal to those obtained by a balanced draft system without the use of blowers, which increased the cost of power required to operate such systems.

Henry W. Geare.

New York City.

Formulas for Bumped Heads

In the editorial in Power of Feb. 9 on "Formulas for Bumped Heads" you failed to mention several with which engineers should be made familiar. Here are some:

Mind everybody's business but your own.

Always butt in where you are not wanted.

If your boss happens to be a large man and tells you that you are not on your job, call him a liar.

Pick out a good husky fireman and kick him in the slats.

Fail to duck your nut when you pass under a low pipe line.

Come home at 2 a.m., stewed to the gills, and tell your wife that you had trouble at the plant and had to work overtime.

These few will no doubt direct a course of investigation which will result in digging up many more "formulas for bumped heads."

E. L. Aine.

Reading, Penn.

Laying Up Boilers

Some years ago I had the opportunity of experimenting in preparing boilers for a long period of idleness. The steam generators consisted of three horizontal-tubular boilers, 100-hp. each, and were in good condition. The feed water being badly incrusting, a boiler compound was used to prevent pitting and corrosion.

Before laying up the boilers they were cleaned inside and out and a coat of red lead spread on all accessible external parts. Boiler No. 1 received the following treatment: The inside was dried and a box of quicklime was put in to absorb any moisture remaining. Before closing, a pan of charcoal was burned to consume the oxygen of the air. The handhole plates were then replaced and the boiler made practically air-tight. Boiler No. 2 was filled with water and 150 lb. of soda dissolved in it, which is equal to 50 lb. to each 100 cu.ft. of water. All openings were then tightly closed. Boiler No. 3 was completely filled with feed water, and all the air was allowed to escape through a valve at the top. In each boiler was hung a polished wrought-iron bar.

Nine months later I was called back to prepare the plant for operation. On opening boiler No. 1, the iron bar was found to be slightly rusted, but the oxide was easily rubbed off with the finger. The bar hung in No. 2 was as bright as the day it was put in. Boiler No. 3 was found to have lost about half its water in some way, leaving the bar above the water line. This bar was badly rusted, the corrosion having eaten into the metal $\frac{1}{32}$ in. My opinion is that the dry method is the best and cheapest, there being no danger of freezing in extreme cold, and no water to leak out.

K. Hudson.

Spokane, Wash.

Reseating a Ball Engine Valve

The following shows what may be done in an out-of-the-way place when there is a will to do it. The valve and valve seat of a Ball engine, Fig. 1, being worn, the valve was sent to the shop and overhauled, but the engine could not be spared long enough to send the cylinder away.

The tool shown in Fig. 2 was made to true the upper seat after the lower one had been leveled and scraped.

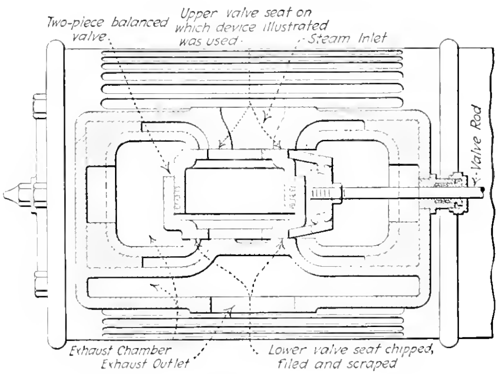


Fig. 1. Type of Valve Operated On

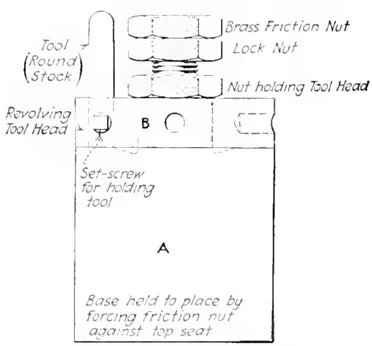


Fig. 2. Tool Used in Truing Valve Seat

It consists of a cast-iron block A for a base and a revolving tool head B. The cutting tool was set away from the center far enough to swing across the width of the face of the seat. Four holes were bored to receive the small bar used to rotate the tool head. The tool was set upon the lower seat and the adjusting nuts set up against the upper seat lightly; the tool was then adjusted to the desired cut, and the head rotated with the bar in one hand, while the base was held steady with the other. The adjusting nut required frequent changing at first, but as the work progressed only slight adjustments were necessary. A surface approximately 8x10 in. was gone over in about five hours, taking a cut from almost nothing to $^3/_{64}$ in. The tool cost $5, making a satisfactory job at a low cost.

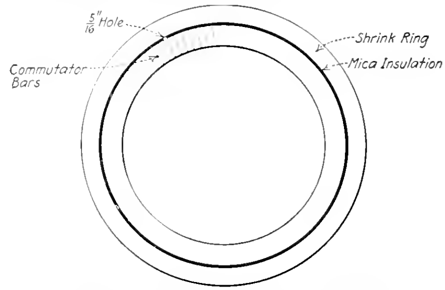
R. A. Jannet.

St. Joseph, Mo.

Quick Repair to Commutator

We have three 1500-kw., 600-volt, direct-current generators for operating a street-railway system. These run at 750 r.p.m., and the commutator bars are held in place by three shrink rings which are separated from the bars by mica insulation.

A short-circuit developed between two of the bars, and



Illustrating How Repair Was Made

investigation showed that it was directly under one of the shrink rings. To save the time and expense required to take off the shrink ring, a $\frac{5}{16}$-in. hole was bored between the two bars showing the short-circuit; it being necessary to drill nearly the whole depth of the shrink ring. After the short was cleared the hole was filled with a composition of mica and shellac, and the machine was put back in service after twelve hours' shutdown and has since been operating and carrying full load without difficulty.

J. B. Crane.

Duluth, Minn.

Air Hose and Bucket as Ammonia Helmet

To be able to remain calm when there is a serious ammonia leak about the plant is a valuable asset to a refrigerating engineer.

The following is an excellent example of the engineer doing the right thing at the right time. He was operating an absorption plant when a serious break in the ammonia end of the aqua pump occurred. Before he could shut the valves the ammonia fumes had become so strong that he was compelled to leave the room. The engineer realized that the charge of ammonia would be lost unless the valves were shut immediately. Reaching in through a window he pulled the air hose loose from the air hoist. He then put the end of the hose into a three-gallon water bucket, and with the hose at the back pulled the bucket down over his head, and with his improvised helmet was able to get at the valves to save the ammonia. The air, which was at a fairly high pressure, blew the ammonia fumes from his face.

G. A. Robertson.

Atlanta, Ga.

Selecting a Pump

Mr. Lent's criticism in the Mar. 9 issue, of the writer's article on pumps in the Feb. 9 number, seems to be devoted largely to deploring the latter's lack of knowledge upon the subject rather than to imparting useful information to replace that which he discredits.

The suggestion that the priming of a centrifugal pump should have been mentioned is a good one. The length of the article, however, did not allow of a discussion of many of the important details relating to the various types mentioned, and this was omitted, with others of a similar nature. Possibly a second reading will bring out the fact that the matter of distance was not the only factor noted regarding the selection of a pump for a given set of conditions.

A deep-well pump having an efficiency over 80 per cent. and no slip, is interesting as showing what can be done through good design and careful adjustment, but is hardly to be taken as current practice. The Deming Co., large manufacturers of this type of pump, give average efficiencies even lower than the ones criticized, while those for triplex pumps are practically the same as given by the writer.

Methods employed for increasing the flow of artesian wells are discussed in detail by Professor Turneaure, in "Water Supply," Part I, American School of Correspondence, and might be of interest to Mr. Lent. The use of the air lift for increasing the flow of artesian wells has been recommended to the writer by the consulting engineer of a large concern making a specialty of sinking wells and installing pumps of various kinds.

Gebhardt's "Steam Power Plant Engineering" gives the efficiency of direct-acting steam pumps as varying from 50 to 90 per cent., according to the conditions under which they are operated, with an average of about 65 per cent. for actual practice. The writer's estimate of 60 to 80 per cent. does not appear to be outside the usual limits. The Lawrence Machine Co. recommends efficiencies of 50 to 60 per cent. when estimating the power for driving centrifugal pumps of the type used for circulating hot water in heating systems, while tests of high-class machines, as given in standard works on pumps and published in the catalogs of the Worthington and De Laval companies, show efficiencies running from 70 to 80 per cent. The range of 60 to 80 per cent., as given in the article, does not seem unreasonable when compared with average results.

Regarding the statement relating to the action of volute and turbine pumps, Gebhardt's "Steam Power Plant Engineering," pages 630-631, may throw some light on the matter.

In brief, the writer has no desire to discredit the views of Mr. Lent or enter into any controversy, but he wishes to emphasize that the statements made in the original article seem to be well supported by authorities of high standing and to be based on average current practice.

CHARLES L. HUBBARD.

Boston, Mass.

Charles L. Hubbard's article, "Selecting a Pump for General Service," in the Feb. 9 issue is of interest, and may be modified and enlarged upon without limit. The following may be of additional interest.

It may be worth while to note that the usual steam consumption for this type of pump is more nearly 200 to 250 lb. per developed horsepower per hour than 80 to 160 lb. The latter would be difficult to obtain under ideal conditions of tight steam valves and pistons working on smooth, polished, well lubricated surfaces, the best hydraulic piston packing, fitting snugly to the water-cylinder barrel, and tight suction and discharge valves. Even this extravagant use of steam is not a serious disadvantage when the pump is installed under proper service conditions, as the exhaust steam can often be used advantageously.

Under normal operating conditions direct-acting steam pumps should not have a slippage of more than 5 per cent., and any pump having 15 to 20 per cent. should receive prompt attention from the operating engineer.

A normal speed of 100 ft. per min. is conservative. Boiler-feed pumps frequently operate at half this rate, while general-service pumps operate satisfactorily at 50 per cent. excess speed. The piston speed of a pump has little or no relation to its proper operation unless the valve area is restricted. The important consideration is the number of piston reversals, hence the number of times the flow of water is interrupted. The higher the speed the lower the steam consumption per indicated horsepower per hour, due to the reduced cylinder condensation.

A single, or simplex, pump is one having a single steam and water cylinder arranged along the same center line. A duplex pump is two single pumps placed side by side, the steam valves receiving their motions from the piston rods of the opposite sides. Owing to its simplicity, positive operation and even rate of discharge, the duplex type is often preferred, although the single pump has a slightly lower steam consumption.

Power Pumps

The power pump has more universal application than the steam pump, because of the extensive use of electricity and the gas and oil engine, to which it is either belted or directly connected. The belt drive is preferable, as it is quieter, more flexible, and provides a safety, which may prevent serious damage to the pump. It is frequently objected to where the pump is to be automatically started and stopped. In such cases, the belt should be selected with care and the drive carefully laid out.

The belt should not be allowed to run slack or slip, as this eventually results in its destruction, and interrupted service. A proper-sized belt, cut from the best hide, thoroughly stretched, carefully made and rightly installed, with an idler for maintaining a constant tension, is a most satisfactory drive and should operate for years. Where an idler pulley is not desired or where there is much moisture, a rubber belt will give more satisfactory service than leather. If the space is limited, a close-belted idler drive is to be preferred to a gear drive, and especially is this so in apartment houses and office buildings, where the noise of the gears may be transmitted through the piping system.

The power pump is much used for elevator, domestic and irrigation service, as it may be conveniently located and long lines of steam pipes are eliminated. The discharge is positive, hence a relief valve should always be placed in the discharge line, close to the pump, to prevent excessive pressure and damage to the pump.

In the larger sizes and where the plunger loads are reasonably large, the efficiency is from 80 to 90 per cent.

A slippage of 15 to 20 per cent., as stated by Mr. Hubbard, is excessive; it should not be more than 3 to 5 per cent. Most power pumps, especially the vertical triplex, are outside-packed and the slippage past the plungers is evident.

Power pumps are either horizontal or vertical; the larger sizes are usually horizontal. Both types are built single, duplex, triplex or quintuplex. The vertical triplex is the most popular high-grade power pump, because of its moderate cost, smooth discharge and generally satisfactory service.

Deep-Well Pumps

This class of pump performs the most severe kind of work, and there are indeed few deep-well pumps which render reliable service year in and year out. There is great difficulty in maintaining the well rods, which frequently reach five or six hundred feet to the water level below the ground, and in some cases of oil wells, three or four thousand feet below the surface. Because of their great length and the large inertia stresses due to the rising and falling column of water, the rods are frequently broken, and until the wreckage can be removed and the rods renewed the service is interrupted.

The vertical artesian steam engine is so cushioned that rod troubles are slight on wells up to 200 ft. deep. The power-well head has troubles all its own, especially on deep wells. The difficulties have, however, been largely eliminated by the triple-plunger barrel and well head, known as the "Glendora" deep-well pump, manufactured by the Deane Steam Pump Co. With this construction the column of water is always moving upward. There is no reversal of stress in the well rods, and the efficiency is 85 per cent. and more, as against 65 to 70 per cent. for the single-acting power-well head.

Mr. Hubbard states that deep-well pump efficiencies are 40 to 50 per cent. This is true only of the centrifugal type. There are installations where centrifugal deep-well pumps give better initial efficiencies, which are maintained only by frequent tuning up.

Centrifugal Pumps

Centrifugal pumps are most desirable for clear water and low heads. Efficiencies of 60 to 80 per cent. are normal, but appear absurd if the slippage is as great as 20 to 60 per cent., as given by Mr. Hubbard. The foregoing, of course, assumes that the pumps are of good design and construction, properly maintained and operating under suitable conditions. It is evident that the discharge head might be so great that there would be no discharge and the slippage would then be 100 per cent. A slippage of 20 to 40 per cent. would be reasonable for a well designed pump operating under the conditions for which it is designed.

A peculiar characteristic of a centrifugal pump is that, as the pressure on the discharge is increased above some fixed pressure for a particular pump, the required driving power is reduced, and, as the pressure is reduced the required driving power is increased. For this reason the centrifugal type is not adapted to fluctuating conditions of service.

Air Lifts

The air lift as a pump would be simple were it not necessarily complicated with compressors and air-storage tanks, which are more or less dangerous and in some states must be regularly inspected by a properly authorized inspector. The efficiencies given by Mr. Hubbard are misleading, as the net overall efficiency is generally between 20 and 30 per cent., with isolated cases of better efficiency.

Hydraulic Ram

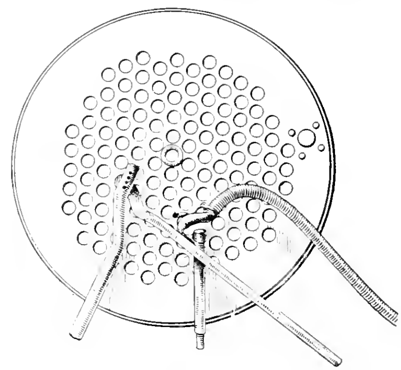
A hydraulic ram would hardly be considered as a pump for general service, and it may be located only where the supply of water is itself elevated.

Robert E. Newcomb,
Supt. Deane Steam Pump Co.

Holyoke, Mass.

An Ingenious Repair Job

A small vertical boiler on a locomotive crane at the works of the Champion Fibre Co. at Canton, N. C., required a new set of flues and an upper flue sheet. Time being the essence of the contract, a novel means was employed by the boiler maker. To avoid the necessity of removing the firebox in order to get inside to hold the "dolly" on the head of the rivets while driving, a piece



Dolly-Bar and Hammer Used on Repair Job

of 3-in. shafting, the right length to reach from the center flue hole to the rivet heads, was prepared, hinged and pinned to a lever put through the center flue opening (which was bushed to prevent injury to the edge).

The new head was fitted in place in the usual way and the riveting process was carried on in the following manner: The heated rivets were passed inside of the boiler to a pair of long, specially made tongs operated, through one of the tube holes in the lower head, by a man stationed in the firebox. He in turn placed the rivet in the proper hole. Then the end of the dolly-bar was brought to bear on the rivet head as described and the pneumatic riveter "turned loose" on the outer end. The cost of the job and the time consumed were, of course, materially less than they would have been if done in the ordinary way.

H. Kilday.

Canton, N. C.

[We presume there were "good and sufficient" reasons for not wishing to invert the heads and drive the rivets from the outside. The rather unsightly appearance of such a job is sometimes objectionable.—Editor.]

Inquiries of General Interest

Temperature for Pouring Babbitt Metal—How can the proper temperature for pouring babbitt metal be known?

F. L.

When a yellowish tinge has formed on the surface, or if a white-pine stick is heavily browned or slightly charred when inserted in the molten metal, then the proper temperature has been reached for pouring.

Disadvantage of Low Boiler Settings—What is the disadvantage of low, as compared with high settings for return-tubular boilers?

C. B. L.

Settings which are too low may be wasteful of fuel, for when a boiler is set too close to the grates the flame is cooled by coming in contact with the boiler surfaces before combustion has been completed.

Calculation of Calorific Value of Coal—How is the calorific value of coal determined from its analysis?

J. M. E.

The heat value of any coal may be calculated from its ultimate analysis, with a probable error not exceeding 2 per cent., by Dulong's formula,

$$\text{Heat value in B.t.u. per lb.} = 146\,C + 620\left(H - \frac{O}{8}\right) + 40\,S$$

in which C, H, O and S are the respective percentages of carbon, hydrogen, oxygen and sulphur present in the coal.

To Draw True Vacuum Line on Indicator Diagram—How is the true vacuum line drawn on a steam-engine indicator diagram?

M. G.

The line representing true vacuum would be below the atmospheric line a distance which represents atmospheric pressure. Therefore, at sea level the true vacuum line is to be drawn with a straightedge below the atmospheric line of the diagram, and parallel to it, at a distance which, according to the scale of the indicator spring, represents 14.7 lb. per sq.in.

Objections to Sulphur in Coal—What are the objections to the presence of sulphur in coal for steaming purposes?

C. R. S.

The calorific value of sulphur is less than $\frac{3}{10}$ that of carbon, and its presence in fuel is objectionable because the gases formed from its combustion attack the metal of the boiler, causing rapid corrosion, especially in the presence of moisture. Sulphur is also objectionable because it unites with the ash of the coal to form a fusible slag, or clinker, which chokes up grate bars, forming a solid mass having embedded in it considerable quantities of unconsumed carbon.

Absolute Temperature—What is meant by absolute temperature?

G. R.

Since substances can be cooled below the zero point of the ordinary thermometer, it does not represent the true zero of temperature at which there is an entire absence of heat; and while this has never been reached in cooling substances, experiments indicate that it is 460 deg. below the zero of the Fahrenheit scale. Hence, to change Fahrenheit degrees to absolute temperatures add 460 to, or to change from absolute to Fahrenheit degrees, subtract 460 from, the number of degrees.

Obtaining Length of Open Belt—What is the rule for finding the length required for an open belt?

R. B.

The best method is to measure the length directly by passing a tape line around the pulleys. When this cannot be done an approximate formula is

$$\text{Length} = 2\,L + 3.1416\,(R + r) + \frac{(R - r)^2}{L}$$

in which all dimensions being in feet or inches,

L = The distance between centers of the pulleys;
R = Radius of larger pulley;
r = Radius of smaller pulley.

Loss of Draft in Flues and Elbows—What is the relative loss of draft in round and square smoke flues and what allowance should be made for elbows and lengths of flues?

W. C.

The retarding effect of a square flue is about ⅛ greater than for a circular flue of the same area, and for brick flues is about ⅓ greater than for steel flues. Short right-angle turns reduce the force of draft about 0.05 in. for each turn and a circular steel flue the same size as the stack causes about 0.1 in. draft loss for each 100-ft. length of flue. In average power plants it is usually practical to reduce the loss of draft by providing a smoke flue with a cross-sectional area about 20 per cent. greater than the cross-sectional area of the stack.

Duty of Steam Pump—What is meant by the duty of a steam pump?

H. N. M.

The duty of a steam pump is the number of foot-pounds of useful work realized, or the equivalent number of pounds of water lifted 1 ft. high, per 1,000,000 heat units furnished by the boiler; i.e.,

$$\text{Duty} = \frac{\text{Foot-pounds of work done} \times 1{,}000{,}000}{\text{Total number of heat units consumed}}$$

The old unit of comparison was the number of foot-pounds of work realized per 100 lb. of coal, and this was inexact, as the amount of steam depended upon the quality of the coal and the evaporative efficiency of the boilers. The modern unit of comparison is not seriously at variance with the old unit, as in good boiler practice 1 lb. of coal will yield at least 10,000 B.t.u. in generation of steam.

Loss of Heat from Steam Pipe—What would be the loss of heat from an uncovered 6-in. steam pipe 80 ft. long, containing steam at 100 lb. gage pressure?

W. B.

Bare pipe will radiate approximately 3 B.t.u. per hour per square foot of exposed surface per 1 deg. of difference in temperature between the steam contained and the external air. The temperature of steam at 100 lb. gage pressure being 338 deg. F., and assuming the temperature of air surrounding the pipe to be 80 deg. F., then the loss of heat would be

$$(338 - 80) \times 3 = 774 \text{ B.t.u.}$$

per hour per square foot of exposed pipe surface, and as the external diameter of 6-in. pipe is 6.625 in., the total pipe area exposed would be

$$\frac{6.625}{12} \times 3.1416 \times 80 = 138.75 \text{ ft.}$$

and the loss of heat would amount to

$$138.75 \times 774 = 107{,}392.5 \text{ B.t.u. per hour.}$$

Equivalent Evaporation—With an average temperature of feed water of 136 deg. F., 2900 tons (each 2240 lb.) of coal were required to evaporate 38,000,000 lb. of water into steam at an average gage pressure of 137 lb. per sq.in. What was the equivalent evaporation from and at 212 deg. F. per pound of coal?

J. A. M.

The evaporation under the actual conditions was

$$\frac{38{,}000{,}000}{2900 \times 2240} = 5.849 \text{ lb.}$$

of water per pound of coal. The steam tables show that 1 lb. of steam at 137 lb. gage, or about 137 + 15 = 152 lb. absolute, contains 1193.6 B.t.u. above 32 deg. F., and as each pound of the feed water contained 136 — 32 = 104 B.t.u., then for conversion into steam at the stated pressure each pound of feed water received

$$1193.6 - 104 = 1089.6 \text{ B.t.u.}$$

As the latent heat of evaporation of a pound of water at 212 deg. F. is 970.4 B.t.u., the factor of evaporation was

$$1089.6 \div 970.4 = 1.1228$$

hence the actual evaporation was equivalent to an evaporation of

$$5.849 \times 1.1228 = 6.567 \text{ lb. of water}$$

from and at 212 deg. F., per pound of coal.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Testing Lubricating Oils*

SYNOPSIS—An enumeration of the various tests to determine the qualities of an oil. Results obtained are only approximate.

A brief description of a desirable lubricant is that its viscosity should be the least possible which will allow it to stay in place and do the work. Summarizing the commonly desirable characteristics, they are:

1. The oil should possess cohesion.
2. It should possess the maximum possible adhesion.
3. It should be as far as possible unchangeable.
4. It should be commercially free from acid.
5. It should be pure, that is, it should be what it purports to be.

TYPES OF VISCOSIMETER

The first to be discussed is the viscosity test, which is used to measure the internal friction of the oil, or, as an engineer might put it, the shearing modulus. This test is of value because a lubricant is really used to keep a shaft or journal and its bearing apart. The journal really revolves on a sheet of lubricant, an action which has been described as revolving on the molecules of the lubricant. The ease with which the molecules slide over one another therefore determines, to a certain extent, the friction loss in a bearing.

A fine example of the effect of the viscosity of lubricating oil is furnished by an experience in a certain spinning mill. This mill was operated with power derived from an engine carrying about the maximum load of which it was capable. The lubricant used on the spindles was changed to one which was supposed to be better. It was then found that the engine did not have power enough to drive the machinery in the mill; as a matter of fact, it was unable to start the machine in motion. Examination showed that the only essential difference between the two lubricants was the possession of higher viscosity by the new oil.

The measurement of viscosity of lubricating oils is in a certain sense unsatisfactory, because the results obtained with the different instruments which are available for making this test do not agree among themselves. It is therefore customary to state the instrument which was used in determining any quoted viscosity.

One of the most commonly used viscosimeters is the Saybolt instrument. This is of the pipette type, having a tall pipette of rather small diameter immersed in a jacket which may be used for maintaining any desired temperature during the test. The test is made by filling the pipette to a certain point and noting the time of efflux, in seconds, which is taken as the measure of the viscosity of the oil tested. Or the so called specific viscosity may be determined by dividing the time required for the efflux of the oil by the time required for the efflux of the corresponding volume of water. The Saybolt instrument was developed by the Standard Oil Co. and was used as a standard for many years, and is today.

The instrument most commonly used in Germany, and now coming into rapid use in this country by both the Government and individuals, is known as the Engler viscosimeter. This differs from the Saybolt principally in using a shorter pipette of larger diameter. It is used in the same way, but the specific viscosities as determined by the two instruments do not agree.

None of the commercial viscosimeters really measure the viscosity, becaues it can be shown that the tube through which a jet is discharged must have a length of from 175 to 200 times the diameter to give a true measure of viscosity. Any of the commercial instruments can, however, be standardized by measuring the times of efflux of standard solutions of cane sugar or of glycerin. By such means the readings of these instruments can be interpreted in terms of absolute viscosity in dynes.

Numerous viscosimeters made of glass have been tried, but unfortunately no two glass instruments can be made exactly alike except at prohibitive expense. For this reason, the glass pipette once used as a standard by the Pennsylvania R.R. was abandoned. It should, however, be noted that a glass pipette, calibrated with glycerin as above described, can be used.

The viscosimeters just mentioned are all of the efflux variety, but there are numerous other forms available, and some of them are particularly well adapted for testing the viscosity of certain commercial products other than oils. For instance, the retarding effect exerted on a paddle revolved in a viscous liquid may be used as a measure of the viscosity and is so used with varnishes, glue and paste. Another form consists of a cylinder suspended from a torsion wire. The retarding effect upon this cylinder when swinging back to normal position after a displacement can be used as a measure of viscosity.

It should be particularly noted that the viscosity varies rapidly with the temperature. It is therefore necessary to state the temperature at which any determination was made.

FRICTION TEST

There is really no satisfactory test of the adhesive quality of a lubricant. It is commonly supposed to be determined by a friction test. This is made by measuring the frictional resistance offered to the rotation of a standard journal in a standard bearing when lubricated with the oil in question. The results obtained depend partly upon the viscosity of the lubricant and partly upon its adhesion. Modern research shows that viscosity tests show about as much as do friction tests, but this is not necessarily so, and must not be assumed to be universally applicable.

GUMMING TEST

A third test, and one which is of great importance, is known as the gumming test. This is particularly applicable to petroleum oils and is used to indicate the extent to which the oil has been refined. It serves indirectly to indicate the extent to which the oil may be expected to change due to oxidation when in use. Numerous opportunities have been offered to check the results obtained with this test and results obtained in practice with the same oils, and all of this experience tends to show the great value of the gumming test.

This test is made by putting a small quantity of the oil to be tested in a small glass vessel, such as a cordial glass, and then mixing with it an equal quantity of nitrosulphuric acid. A properly refined oil will show little, if any, change, but a poorly refined oil will be indicated by the separation of large quantities of material of dark color. This color is due to the oxidation of the tarry matter contained in the lubricant. Experience has shown that oils containing large percentages of tar absorb the most oxygen, that is, they are mildly drying oils.

The results obtained by the gumming test agree well with carbon-residue tests made by distilling to dryness in a glass or a fused quartz flask. The carbon-residue test has been found of great assistance in choosing a satisfactory cylinder lubricant for gas engines, as a large amount of carbon means trouble in the engine cylinder. The lowest carbon content mentioned by the author was 0.11 per cent. The oil giving this test showed no tarry matter when tested with nitrosulphuric acid. In general, a gas-engine oil should not contain more than 0.5 per cent. carbon as determined by the carbon-residue test.

FLASH, FIRE AND EVAPORATION TESTS

When an oil has been found to have satisfactory viscosity and has given satisfactory results in a gumming test, it must next be checked for safety, that is, the flash and fire test must be made. The amount of volatile matter given off at the temperature at which the lubricant is to be used is often of great importance. A case is on record in which a serious mill fire was spread by vapors given off by the lubricant used in the various bearings. The oil used in this mill gave off 25 per cent. of volatile material when raised to 145 deg. F.

It is advisable to include an evaporation test with the flash test of lubricants. The evaporation test is made by exposing about 0.2 gram of oil at a proper temperature and determining the loss by weight in a given time.

The flash test is made by heating the oil slowly in a vessel surrounded by a proper bath and determining the lowest temperature at which a flame passed over the surface will ignite the vapors which are given off.

FREE ACID TEST

It is generally conceded that lubricants should be practically free from acid, and the so-called free acid test is made to determine the extent of acid content. The mineral oils are agitated with sulphuric acid during the refining process for the purpose of removing tarry materials, and this acid must be practically all removed from the oil before it is put on the market. Oils may become contaminated with acid from another source as well; namely, the animal or vegetable oils which are occasionally mixed with them for the purpose of

*Abstract of paper read by Prof. A. H. Gill before the Detroit Engineering Society, Mar. 19, 1915.

modifying their characteristics. A content of 0.3 per cent. of acid is generally considered the maximum allowable.

SPECIFIC GRAVITY

It is often desirable to determine the character of the raw material from which a given lubricant was made. This can be done in the case of oils refined from petroleum by means of the specific-gravity test. Experience has shown that lubricants made from petroleum with an asphaltic base run from 7 to 10 deg. Baumé heavier than similar lubricants made from petroleum with a paraffin base.

In examining oils, it is well to bear in mind that the viscosity is easily increased by the use of a material known as oil pulp or oil thickener. This is really oleate of alumina, and while it brings up the viscosity, it does not give the greasiness expected when that particular viscosity was specified. At ordinary temperatures, a small quantity of this material will greatly raise the viscosity.

COLD TEST

There is another test, known as the cold test, which is of value in some cases. If an oil is to lubricate a bearing, it must be fluid enough at the temperature of use to readily flow into that bearing. Many ruined bearings and some fires have resulted from the use of an oil which became too viscous to flow under the conditions of use. For such reasons, it is customary to chill samples of oil and to determine the temperatures at which they become too thick to flow readily.

IODINE TEST

Tests other than those already described are often made on animal and vegetable oils. They are generally made for the purpose of determining whether the oil under test is what it is supposed to be. It is a simple matter to mix different animal and vegetable oils in such a way that they will give a product capable of passing any one or possibly two given tests, but it is impossible to make such a mixture successfully pass all of the tests which would be passed by the pure oil for which the mixture is to serve as a substitute.

The chemist is often at a great disadvantage in testing such mixtures, because there are no exact specific tests for some of the animal and vegetable oils. The presence of some can be determined absolutely, but unfortunately, this is not true of all.

The iodine test, by which is meant the determination of percentage of iodine absorbed by the oil under set conditions, has long been used to indicate the character of vegetable and animal oils present in a sample. At one time it was believed that the so-called iodine number was a constant for any one oil and that this test was therefore perfect. It is now known that this is not true, the iodine number varying with the condition of the material from which the oil was made.

It is a simple matter to determine the presence of petroleum oils in a mixture of oils with animal or vegetable origin. This is done by saponification, which serves to separate the petroleum oil, which does not saponify, from the others which do.

MAUMENÉ TEST

There is a comparatively new test, known as the Maumené test, which gives results comparable with those obtained with the iodine test, but is much simpler and therefore more readily performed by the average individual. For this test, 50 grams of oil and 10 c.c. of sulphuric acid are placed in a beaker and slowly stirred with a thermometer. The maximum temperature rise which occurs is noted and used as an indication of the character of the oil.

TESTS ONLY APPROXIMATE

It should be appreciated by the practical man that the tests of lubricating oils give only approximate results. Thus any one viscosimeter as ordinarily made will give consistent results on the same material at the same temperature, but different instruments of the same type and apparently exactly alike will give results on the same material which vary several per cent. Similarly, large errors are often obtained when using friction machines. With tests otherwise properly conducted, it appears that the absorption of oil by the metal of the journal and bearing may be sufficient to cause appreciable errors. Tests have shown that it may take several hours to eliminate the effects of the last oil tested so as to get correct results with a given sample.

No rigid directions can be given for the choice of oils for given purposes. It is best to try various lubricants which can be purchased for any given lubricating problem until one is found which gives satisfactory results. This should then be completely tested and the results of the test should be used in writing specifications on the basis of which bids are to be asked. When the problem is handled in this way, the different prices asked for lubricants which will meet the same specifications will often be found most remarkable.

Wrought Iron and Steel Tubes*

By J. G. Stewart

When the British Engineering Standards Committee considered the question of screw threads for pipes they compared the merits of two well known forms of thread, viz., the Whitworth or British standard bolt thread, the Sellers, or U. S. A. standard, and another, not so well known—the Briggs American standard pipe thread. The committee decided by a majority (of which the writer was not a party) to accept the Whitworth thread, principally because the tools to make it were already in the hands of every engineer and plumber in this country, but also because taps and dies made to this form have little tendency to change by wear, which is not the case with the American standard forms of bolt and pipe joints.

However, any pipe joint, in order to be petroleum tight under high pressure (many oil lines work at 1000 lb. per sq.in.) must be of very special and accurate construction, and for this class of work the Briggs thread has alone proved satisfactory. It will be noticed that the crest of the thread is very sharp, much more so than the contour of the root. One result of this is that a difficulty occurs in maintaining the screwing tools to their correct shape. This is minimized by forming the tools to the correct profile by a single cutting tool which leaves the sharp crests on the master tap. As there is a considerable amount of cutting surface to be worn away on the master tap, the sharp edges stand up to their work for some time without losing appreciably the sharpness of the thread.

The difference in the power required to draw up a coupler with the Briggs thread, as compared with one with the Whitworth, is marked, particularly as such threads are made on a cone with a taper of $\frac{1}{16}$ in. per inch. With the Whitworth thread little movement can be given to the coupler with a heavy pipe wrench, after it has been drawn up by hand, as compared with that which can be obtained in a Briggs thread joint. There is little doubt that Briggs himself, in putting it forward in his paper which was read in America in 1886, fell into confusion. His description of his proposed thread, which was subsequently adopted as the American standard pipe thread, is as follows: "The thread employed has an angle of 60 deg.; it is rounded off top and bottom, so that the height or depth of the thread, instead of being exactly equal to the pitch, is only four-fifths of the pitch." But, having an angle of 60 deg., the depth could not be equal to the pitch. There can be no doubt that what he meant to say instead was "the depth appropriate to the pitch." This depth measures 0.866 and as the depth was to be 0.8 the amount to be taken off the sharp edge or crest was 0.066, as against 0.17 on the Whitworth standard.

The question arises, Can a joint be made in this manner—i.e., with the Briggs thread—be undone, and remade if occasion arises? The answer is that it depends upon the treatment given when the joint is first made. If the couplings are driven very hard upon the screwed ends of the pipes it may be found impossible to disengage without injury to the thread and again remake the joint. But if the joints are screwed up with proper care and with a liberal use of thick viscous oil, these joints with this form of thread can be unmade and remade five times at the least computation.

Many engineers are under the impression that a coarse thread is stronger than a fine one, but that the converse is the case may be readily demonstrated. Take a pipe or bolt, and screw it at one end with a fine thread and with a coarse thread at the other, with nuts to correspond; place a spiral spring between them and draw up until one of the threads strips. This will invariably be found to be the coarse thread.

An important item in drawing up a specification for steel pipes is the method of bending them to the required pattern. There are two ways in which a steel pipe may be bent. The straight length of pipe may be set on a table between supporting dogs and bent by drawing the free end of the pipe against the dogs. By this method the pipe is constantly under the observation of a skilled operator, who is careful to arrest any local drawing of the metal on the outside radius, by causing the pipe to thicken on the inside radius rather than to reduce on the outside. The other way is to bend the pipe between a pair of dies, each forming a half-mold of the bend to be made. Curiously enough, some engineers seem to be under the impression that the correct way to

*Abstracted from a paper read before the Institution of Engineers and Shipbuilders in Scotland, Feb. 16, 1915.

form a bend is by dies, whereas the two methods will not stand comparison.

When a piece of tube is bent into a curve, first, one side of the tube must stretch or become extended in length; secondly, the opposite side must, in a lesser degree, become shortened; and, thirdly, the cross-section of the tube must become an ellipse. Condition No. 2 is no disadvantage, and condition No. 3 can in most cases hardly matter, as the cross-sectional area is only slightly diminished. The consequences of No. 1 may seriously injure the bend, the result being a reduction of the thickness of the wall, even to the extent of rupture; this does actually take place frequently when the radius of the bend has a small ratio to that of the cross-section of the tube.

It follows that in making a bend it is desirable to control and relieve the stretching at the expense of the other two conditions. The only way of exercising this control is for an expert workman to watch the action and cool the part where he can detect thinning. Along the outside of the bend it will be more prevalent at one point than at others, and wherever it is apparent it will accentuate itself as the metal gets more attenuated and weaker. An experienced bender will stop the bending and cool the yielding part by a water jet before resuming. He may require to cool many parts many times before he completes the operation of forming his bend. This manipulation is quite impossible if the forming is done between a pair of dies.

No doubt, bending pipes in dies is a more expeditious process, suited to unskilled labor, and therefore cheaper, but the quality of the work is altogether inferior. Bending of pipes in dies should never be employed or sanctioned for anything but the sizes of pipes of, say 2-in. bore and under. To confirm this opinion one has only to drill holes in the back of two pipes bent by these two processes, when the difference in thickness of the metal will at once establish the superiority of the first mentioned method.

I have purposely avoided reference to the controversial subject of the relative merits of steel and cast iron for pipes. Some years ago, when steel pipes were introduced for the gas and water supply of our Colonial possessions and other markets far removed from the manufacturing centers, these light lap-welded tubes proved of inestimable value in developing new towns and colonies, which, had it not been for their low cost and the low freight on them, would in many cases have been without water supply to the present day. With very few exceptions these pipes have given every satisfaction, recent reports from all sides showing that they are practically as free from corrosion as when laid. This being so, there is a natural disinclination to pay the extra price and freight charges of the thicker hot-rolled weldless pipe.

As regards its application to water and gas pipes, the total value of steel pipes for that purpose manufactured last year in this country was about £7,000,000, or three times as much as it was 15 years ago. The steel pipe maker, therefore, has certainly nothing to complain about. I believe that during the same period, the production of cast-iron pipes has remained about stationary, but I have no definite statistics on this point.

A few representative cases may be cited as illustrating that the rapid transition from cast iron to steel indicated by the above figures is well warranted. For the water supply of Perth, Western Australia, a cast-iron pipe 12 in. diameter was laid about twenty-five years ago, and this was supplemented 17 years ago by a steel pipe 21 in. diameter. The former has been twice scraped to remove the internal nodular incrustation due to rust, some of these nodules being found to be from 2 to 3 in. thick. On the other hand, the steel pipe, on recent inspection, was found to be practically free from corrosion. This case is remarkable from the fact that the water is from the same source and practically identical with that pumped through the celebrated 350-mile line of 30-in. steel pipe for the water supply of Coolgardie, the internal corrosion of which in places (principally due to portions of this pipe line being allowed to run only half full, that is, between wind and water) has led to a good deal of extravagant comparison of the relative corrosion-resisting qualities of steel and cast iron coupled with the assertion that the laying of this main in steel was a false economy. The real facts of the case are that the local authorities knew full well from the above-cited experience in the Perth water supply that any trouble experienced with this main in steel would certainly have been very much worse in cast iron.

Sixteen years ago the town of Bradford laid about 15 miles of 36-in. steel pipes. At that time there was a difficulty in supplying bent pipes of this size, and the bends in the line were therefore furnished in cast iron. A recent landslide at one of these bends dislodged the leaded socket between the straight steel pipe and the cast-iron bend, when it was found that the surface of the cast-iron pipe was heavily incrusted, owing to corrosion, thus seriously reducing the capacity of the pipe, but the steel pipe was found to be in almost the same condition as when laid, with the glossy surface of the Angus Smith's solution practically intact as originally applied 16 years ago.

Twenty-two years ago Vancouver actually risked its water supply with a 16-in. steel main only ⅛ in. thick. Inspection of this main last year demonstrated that the estimate of steel was not exaggerated, this very thin pipe being so little affected by corrosion that the engineer estimated its life to be worth at least another twenty-five years.

Thirty-three years ago the Kimberley Water Co., South Africa, laid down a wrought-iron water-supply main 14-in. and 18-in. diam., and ¼ in. thick, of which the present manager stated early this year: "With the exception of the portion which runs through a salt marsh, and which was replaced some three years ago, the pipe line is in as good a condition as when it was put down, and we do not anticipate any trouble for at least another twenty-five years."

I have selected the above cases for citation, because they represent pioneer work in four continents, and have led to the very general adoption of steel pipes throughout Australasia, Canada and South Africa, while the favorable experience of Bradford is now leading to the adoption of steel for the water-supply mains of some of the largest industrial centers in the country.

Years ago steel established itself as the material for high-pressure steam-boiler feed, and all other high-pressure service. In addition to the large number of steel, steam, feed, boiler and general service tubes to be found on every modern steamship (the boilers of the "Lusitania," "Mauretania" and "Aquitania" alone contain 100,000 fire tubes), the saving in weight effected by tubular construction has led to its adoption on board ship for many purposes where other sections and materials were formerly used.

Upon the general question of whether the experience of the last few years would warrant the conclusion that the weldless processes of tube making have now been developed to the stage that they will, in the immediate future, in competition with the welded tube, emerge triumphant, and that after all the difficulties which for so many years have accompanied these efforts continuously, I can only say this: In Germany, where the weldless process has been most sedulously pursued, the older methods of making tubes have not been developed and improved in any degree approaching to the way in which these older systems have been advanced by the Americans, and in this country.

I have had many opportunities of seeing tube works in Germany and in the United States, and I am convinced of this—that if the Germans had devoted as much labor of mind and as much of money to the improvement of their welding plants as they have upon experiments on weldless processes, their competition would have been much more severely felt here.

To summarize, the question is this: Can we produce by the old-established, known method of making tubes a tube as reliable as one made by the weldless process, and produce it so as to be able to sell it at the same price? In this country we can, and in America it is still possible. Commercially, the two processes have nowhere met each other on equal ground.

There has also existed, very generally, a theoretic prejudice in favor of the word "weldless," which has proved strong. In Germany the weldless process is universal. In this country and in the United States it is almost non-existent. Of course we all know how often we have been told that the Germans are beating us in everything, and how miserably incompetent and antiquated in their methods our manufacturers are, but we do not often hear the Americans branded as prejudiced fools, unable to take care of their own interests. The question is sometimes put thus: Is a tube any better for having a weld? No one can pretend that it is, and when a weldless tube can be produced of as reliable material and at about the same cost as a welded tube, the days of the latter will be numbered. That that day has not yet arrived is manifest, but that it is always growing nearer is certain.

A Year's Boiler Explosions

The annual report of the Marine Department of the Board of Trade upon the working of the Boiler Explosions Acts during the year ending June 30, 1914, is now before us.

The number of explosions, 68, and the number of lives lost thereby, 22, are both below the average, but the number of people injured, 74, is above the average. This is an exact reversal of the state of affairs set out in the immediately preceding report. Twenty-eight of the "boiler" explosions reported upon resulted neither in loss of life nor in injury to limb. The 96 casualties are thus attributable to 40 explosions. The report is distinguished by the record of an unusually disastrous explosion. On Aug. 26, 1913, a Beesley boiler, 22 years old, failed at the works of Walter Scott, Limited, Hunslet, Leeds, killing 9 men and injuring 18. Investigation showed that the center flue tube had become worn out and that its first ring had collapsed for its full length and had fractured circumferentially. The insurance company, its assistant engineer and one of its inspectors were found to blame, and had to pay costs totaling £600.

Twenty-nine of the explosions occurred to "boilers" which were under the inspection of public bodies, but in 14 of these cases the explosions were not due to material defects, and therefore presumably could not have been guarded against by inspection. Of the causes of the explosions, deterioration or corrosion is most prominent, with 20 cases. Defective design or undue working pressure was responsible for 19, defective workmanship, material or construction for 12, ignorance or neglect of attendants for 9, and water hammer and miscellaneous causes for 4 each. As for the types of boilers which exploded, the horizontal multitubular was the greatest offender with 13 cases. Vertical boilers came next with 7. Tubes in steam ovens were responsible for 5, locomotive boilers for 4, while Lancashire, Cornish and other flue boilers resulted in 3 and water-tube boilers in 2 explosions. Steam pipes, stop-valve chests, etc., are classed as boilers in the acts, and these are debited with 11 explosions. There are three cases of pipes failing by fatigue caused by vibration. In one case it was a cast-iron feed-water pipe, 21 years old. In the two others the parts which failed were the main steam pipes, one being sixteen months old and the other but two months old. There are two cases of failure by fatigue caused by expansion and contraction. In one a cast-iron steam pipe 28 years old was concerned, and in the other the front end plate of a single-ended marine boiler 8½ years old was the part at fault.—"The Engineer," London.

ENGINEERING AFFAIRS

The Annual Dinners of The Atlantic City Association N. A. S. E. are always a success in point of attendance and speakers. The latest, given Mar. 20, was in keeping with all previous ones. The guests of the evening were Col. Lewis T. Bryant, Commissioner of Labor for New Jersey; George R. Starrs, of the Paterson, N. J., Board of Education; and A. L. Case, of the Engineers and Firemen's License Bureau. Other representative N. A. S. E. men and city officials were present.

Atlantic City N. A. S. E. and Guests at Dinner

Detroit Chief Engineers Dine—The second annual banquet of the Chief Engineers' Club of Detroit, Mich., was held at the Hotel St. Clair, Mar. 13, 1915.

This club, which has been in existence only three years, is composed solely of chief engineers, and to be eligible to membership one must occupy the position of chief engineer in some steam plant. At the first annual banquet there were 42 present. This year 86 attended.

Immediately following the banquet there was a vaudeville entertainment given by stars from some of the leading Detroit theaters. The affair was under the direction of the entertainment committee, J. H. Roberts, chairman.

Following is a copy of the menu card:

BILL OF MATERIAL

Exciter — Smooth On
Bleached Fiber — Ball Bearings
Center Punches
Feed Water Agitators

Detroit Chief Engineers' Club Dinner

Aggressor | Carbon Brushes
Electrified Voltage
Aëroplanes
Gas Producers | Aggregate
Silencer | Circuit Breakers
Cement Pats
Refrigerator | Assorted Gaskets
Treated Feed Water | Fuel Testers

The executive committee for 1915 is as follows: Past-president, Charles Mery; president, John Gretzinger; vice-president, Alex Warner; secretary, H. C. Hayes; financial secretary, Edward Kahl; treasurer, Alex Kothe; marshal, F. J. Linck; assistant marshal, J. P. Field; entertainment committee, J. H. Roberts.

Ohio Adopts the A. S. M. E. Code

The following "Special Notice" has been issued by the chairman of the Ohio Board of Boiler Rules.

The Ohio Board of Boiler Rules at their meeting on Mar. 25, 1915, adopted the following resolution:

Until further notice, an Inspector holding a Certificate of Competency and a Commission authorizing him to inspect steam or hot-water boilers which are to be installed within the State of Ohio, is hereby authorized to inspect during construction and on completion stamp "OHIO STD" with Serial Number any boiler constructed in accordance with Rules formulated by the Boiler Code Committee as submitted to the Council of the American Society of Mechanical Engineers on February 13, 1915.

OHIO BOARD OF BOILER RULES,
H. V. NEFF, Chairman.

Mar. 29, 1915.

New Orleans Likely to Have Municipal Plant

That the City of New Orleans will have a municipal lighting plant, involving an ultimate outlay of from five to six million dollars, became apparent Mar. 15, when it was announced that engineers sent by George F. Bishop, of Cleveland, to make a survey of the proposition had completed their work and would soon make a report. There has been organized agitation for a municipally owned plant in the Southern city for many months and the New Orleans Railway & Light Co., which is at present supplying electrical energy for the city and private consumers, apparently isn't so powerful a factor in the city and state affairs as it used to be. The present street-lighting contract with the company expires Sept. 30 but, according to Commissioner E. E. Lafaye, whose department would have jurisdiction over the municipally owned plant, it will not be necessary to execute a new contract on that date or to make other arrangements, as the contract may be extended so as to give sufficient time for the construction of the municipal plant should that be decided upon.

BUSINESS ITEMS

Arthur D. Little, Inc., chemists and engineers, of Boston, are establishing an office in the Chemists' Building, 50 E. 31st St., New York.

Harry B. Aller now has charge of the Chicago territory of the Ohio Injector Co. He will handle its complete line of stationary power-plant equipment.

The Southwark Foundry & Machine Co., Philadelphia, Penn., is now actively engaged in the manufacture of hydraulic and steam hydraulic presses and has a considerable volume of this work in hand at the present time.

A correction—The advertisement of the Girtanner-Daviess Engr. & Contr. Co., St. Louis, Mo., in the Mar. 16 issue read "Sixteen installations since Jan. 1, 1915." This should have read "Twenty-two installations since Jan. 1, 1915."

G. L. Simonds & Co., 500 Gaff Bldg., Chicago, Ill., sales department of the Vulcan Soot Cleaner Co., has been awarded the contract for 18 Vulcan soot cleaners to be applied to 18 Keeler boilers to be furnished for the Illinois State Board of Administration.

A souvenir card being sent out by Yarnall-Waring Co., Chestnut Hill, Philadelphia, is a moving picture of the Simplex seatless blow-off valve. It is really a valve model and shows the construction and operation of the valve in detail. Sent on request.

The Hoppes Manufacturing Co., of Springfield, Ohio, recently made a sale of two 1,000,000 lb. per hr. Hoppes V-notch recording meters to the West Penn Traction Co., Pittsburgh, Penn. This is believed to be the largest installation of feed water metering equipment in the world and will be operated in connection with Hoppes feed water heaters.

The Lagonda Manufacturing Co., Springfield, Ohio, has just published a booklet entitled, "Lagonda Boiler Room Specialties." This booklet describes and illustrates the several types of Lagonda boiler tube cleaners with latest improvements and boiler quick repair tools. It also covers the Lagonda automatic cut-off valve and multiple strainers. Copy may be had on request.

The American Pulley Co., of Philadelphia, Penn., manufacturer of the celebrated "American" wrought-steel split pulley, has just completed arrangements for the opening of its own store at 119 Jackson St., Seattle, Wash., where it will carry a large and complete stock of pulleys for the accommodation of dealers in the Northwest. Archie Chandler, of Seattle, will represent the company in the distribution of its product among dealers on the Pacific Coast.

The Buffalo Forge Co., Buffalo, N. Y., has recently received contracts for heating and ventilating apparatus for the following public buildings: Private Ward Hospital, Wilkes-Barre, Penn.; Southwark Public School, Philadelphia, Penn.; Merchants National Bank, Richmond, Va.; Union High School, Alhambra, Calif.; High School, Compton, Calif.; El Paso Telephone Co., El Paso, Tex.; public school, Garden City, S. D.; Concordia Club, San Francisco, Calif.; Bloomsburg church, Bloomsburg, Penn.

Practically all the sizes and types of Edison Mazda multiple lamps are affected by reductions in list prices that were put into effect Apr. 1, by the Edison Lamp Works of General Electric Co. On the regular straight side and round bulb lamps, from the 10-watt to the 250-watt sizes, also on sign lamps, stereopticon lamps, etc., the reductions range from 3 to 20c. per lamp, according to the size.

On the gas-filled, multiple lamp of 100- to 1000-watt sizes, the reductions range from 50c. to $1 per lamp, the average reductions being between 20 and 25 per cent.

On Jan. 1, Lee H. Parker became president of the Spray Engineering Co., 93 Federal St., Boston, Mass., maker of Spray cooling equipment and air washers. Mr. Parker's experience in the engineering field has been unusually broad, he having severed a connection of 10 years with the Stone & Webster Co. to assume his new duties. Previous to this connection Mr. Parker had been for six years with the General Electric Co. and had also for some time represented large English engineering interests in South America. Mr. Parker was graduated from Cornell University in 1889 with the degree of M. E.

For the territory comprised by Kansas, Nebraska, southern part of Iowa and western part of Missouri, the McIntosh & Seymour Corporation, of Auburn, N. Y., has appointed as its agent Stanton A. Hadley, 621 Delaware St., Kansas City, Mo. Mr. Hadley is interested in the machinery-supply business of Hadley-Hudson Co., Kansas City, but in the future wil devote his whole time to the sale of McIntosh & Seymour Diesel type engines and steam engines and Gould pumps. Previously district manager for the Griscom-Russel Co., of New York, Mr. Hadley was prior thereto contractor, machinery salesman, erecting man and earlier with the A., T. & S. F. Ry.

The Manati Sugar Co., in the Province of Oriente, Cuba, with offices in New York City, has recently placed an order with the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Penn., for electric motors to drive all of its machinery in its new mill with the exception of the engine-driven rolls. This order covers a total of 32 alternating-current motors, having a total capacity of 1042 hp. All of the auxiliaries in this next extension of the Manati Sugar Co. will be motor driven, these auxiliaries including cane and bagasse conveyors, centrifugal pumps, crystalizers, agitators, etc. All of the new material will be in operation for the 1915-1916 grinding, and the electrical equipment will be delivered in time for this operation.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., APR. 1, 1915,

of Power, published weekly at New York, N. Y., required by the Act of August 24, 1912.

Editor, Fred R. Low, 10th Ave. at 36th St., New York, N. Y.
Managing Editor, Henry R. Cobleigh, 10th Ave. at 36th St., New York, N. Y.
Business Manager, William Buxman, 10th Ave. at 36th St., New York, N. Y.
Publisher, Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.
Owner, Hill Publishing Company, 10th Ave. at 36th St., New York, N. Y.

Owners of 1% or more of Stock Issued.

John A. Hill, 10th Ave. at 36th St., New York, N. Y.
Fred R. Low, 10th Ave. at 36th St., New York, N. Y.
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Fred S. Weatherby, 1600 Beacon St., Brookline, Mass.
Frederick A. Halsey, 356 W. 120th St., New York, N. Y.
G. Eugene Sly, 50 Union Sq., New York, N. Y.
Frederick W. Gross, 215 E. 11th St., Erie, Pa.
Alfred E. Kornfeld, 10th Ave. at 36th St., New York, N. Y.
Emma B. Hill, 80 Munn Ave., East Orange, N. J.

The balance of the stock issued (less than 1% each) is owned by 71 employees, 4 ex-employees, and 14 others who are wives, daughters or relatives of employees.

Known bondholders, mortgagees, and other security holders holding 1 per cent. or more of total amount of bonds, mortgages or other securities. Mortgage on building held by Dime Savings Bank, Brooklyn, N. Y.

C. W. Dibble, Vice-President,
HILL PUBLISHING COMPANY.

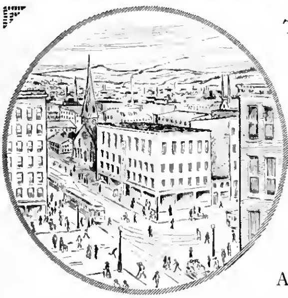
Sworn to and subscribed before me this 31st day of March, 1915

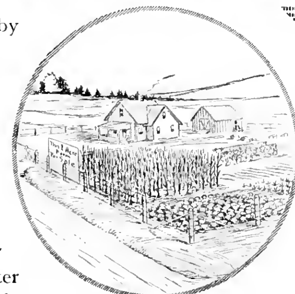
RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1917.)

POWER

Vol. 41 NEW YORK, APRIL 20, 1915 No. 16

The Seventy-Fourth St. Turbine





The condensing water daily required by the turbine is as great as the daily water consumption of any one of the following cities: Hoboken, N.J.; Manchester, N.H.; Saginaw, Mich.; Binghampton, N. Y.; Charleston, S. C.; Galveston, Tex.; Norfolk, Va.; Stamford, Conn.; Chattanooga, Tenn.; Woonsocket, R. I.; Superior, Wis.

Approximately 100,000,000 gal. of water would be required for the condenser for a 24-hr. run at the rated load of 30,000 kw. The cross-sectional area of the intake tunnel is more than 138 sq. ft.

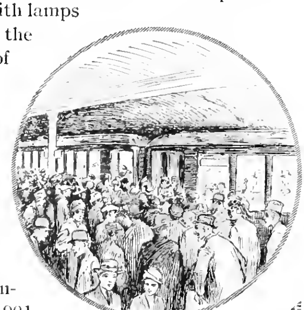
At 1.30 lb. coal per kw.-hr. and 24 hr. a day service, the turbine will use 504 tons of coal. It would require a train of 14 cars, each carrying about 35 tons, to haul a day's supply. A good miner would be 51 days getting out enough coal to last the turbine unit one day.

One of the Westinghouse "Cross-Compound" Turbines for the 74th Street Station of the Interborough Rapid Transit Co., New York City.

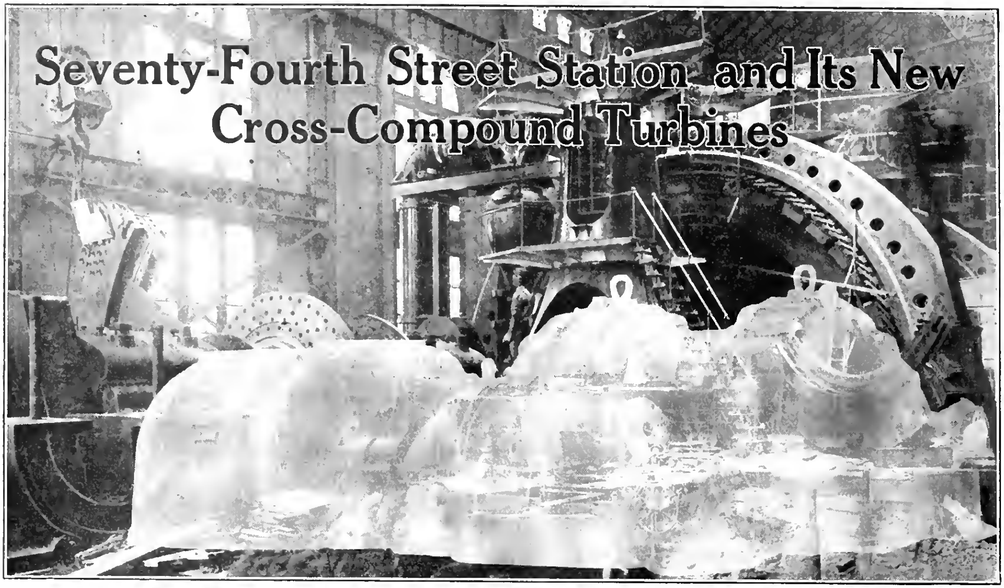
The turbine will furnish power for electric railway traffic. It can haul at one time a line of people 36 miles long, allowing a space of only two feet between each person. Used solely for illumination with arc lamps it could light an area of 40 sq. miles with lamps arranged as in lighting city streets. For the same output the higher economy of each of these turbines would effect a saving of approximately 240 tons (2000 lb. each) of coal every 24 hr. over the consumption by the engines which they displace.

Based on 24-hr. operation and with coal at $3.00 per ton this would mean a saving of over $700 a day for each turbine. The old Manhattan-type engines were installed in 1901.

If the condenser tubes were slit and flattened out there would be enough metal to completely cover over an acre of ground. Placed end to end the tubes would extend 36 miles. The tubes are each 1 in. diameter, No. 18 gage and are all of admiralty composition.



Seventy-Fourth Street Station and Its New Cross-Compound Turbines



By Charles H. Bromley

SYNOPSIS—What the installation of 30,000-kw. cross-compound turbines has meant for the Seventy-Fourth Street station of the Interborough Rapid Transit Co., New York City. Many excellent views of the turbines, and of the station during their installation, are shown. A table of ratios and important data concerning the station forms a valuable part of the article. See also the Foreword in this issue.

"The 5000-kw., direct-connected units now being built by the E. P. Allis Co., of Milwaukee, for the main power station of the Manhattan Railway Co., at Seventy-Fourth and Seventy-Fifth streets on the East River, New York City, are the most powerful steam-operated machines of which we have any knowledge outside of the engines of the great ocean steamers."

So reads the opening paragraph of the leading article in Power for June, 1901, which describes the units installed in the Seventy-Fourth Street station of the present Interborough Rapid Transit Co. These units were the last word in large stationary steam engines. Yet three have been, and a fourth is being, broken up for junk despite the fact that they were in as perfect physical condition and that their economy was as good, as a month after installation.

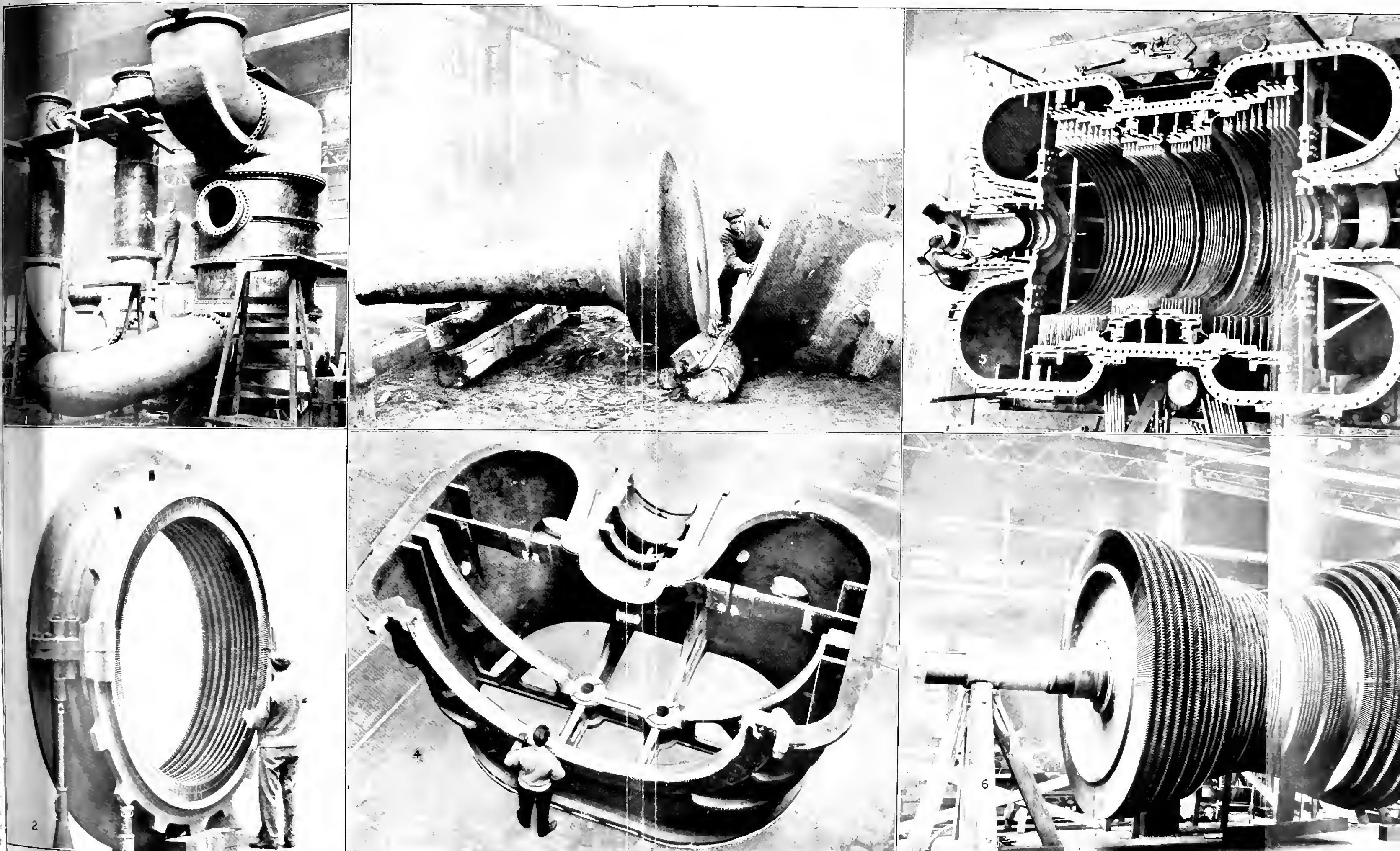
A Notable Example of Obsolescence

Amid the din of rock drills, hammer blows, rumbling cranes, the hum of turbines and the clack of releasing valve gears, this station is rapidly developing from the old to the new. Yet it is little more than a decade since these units were installed. Such is the rapidity of power-plant progress, such the ruthlessness of obsolescence.

As is generally known, these old units have two cross-compound engines each—the low-pressure vertical, the high-pressure horizontal—connected to a common crankshaft. The rated capacity of each is 8000 hp., but at one-third cutoff, 150 lb. initial pressure, 26 in. vacuum and 75 r.p.m., each can develop a maximum of 12,000 hp. The guaranteed steam consumption (dry saturated), under the above condition but for normal rating, was 13 lb. per i.hp.-hr. Today the consumption is nearly the same, being 17.3 lb. per kw.-hr.

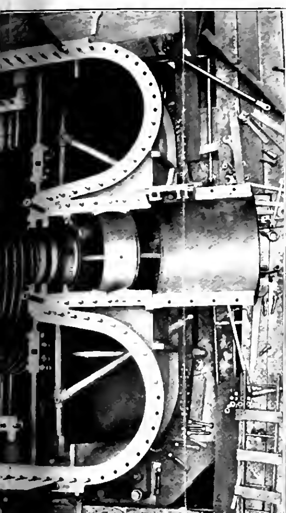
Why Low-Pressure Turbines Were Not Installed

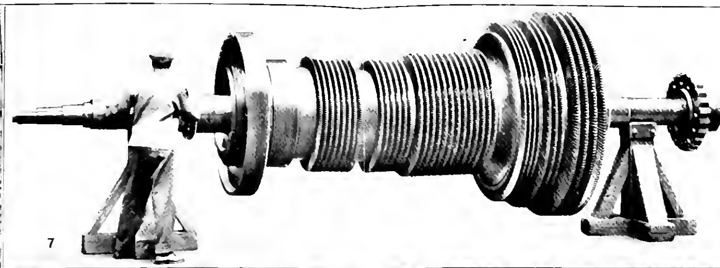
The economy and the excellent physical condition of the units have caused many to wonder why low-pressure turbines were not connected to them, as practiced with such satisfactory results at the company's Fifty-Ninth Street station. Briefly, the chief reasons are these: First, the economy of the turbine as a prime mover at the time of the Fifty-Ninth Street installation was not nearly as good as at present. Secondly, the engines at Fifty-Ninth Street, in addition to being in excellent physical condition, were designed for a higher pressure than those at Seventy-Fourth Street, and, quite important, they have poppet valves in the high-pressure cylinders, adapting them to high-pressure superheated steam, while this advantage is not possessed by the Corliss-valve units at Seventy-Fourth Street. Thirdly, the complete expansion turbines (turbine and generator combined) now going in at Seventy-Fourth Street were bought at a comparatively low figure—about one-third the price per kilowatt paid for the engine units. Fourthly, it is necessary to economize on space at Seventy-Fourth Street, and complete expansion turbines accomplish this far better than combination units. For a more exhaustive analysis of the reasons for the selection of low-pressure turbines for the Fifty-Ninth Street station and of complete expansion turbines for Seventy-Fourth Street, see the article by the writer in Power, Mar. 24, 1914, page 398.

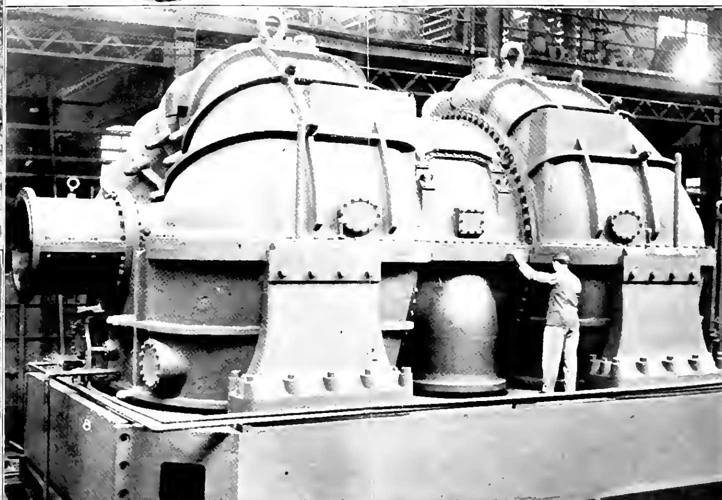


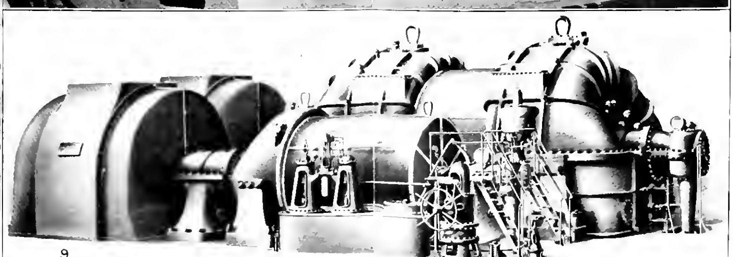
Parts of the Westinghouse 30,000 Kw. "Cross-Compound" Turbine for the 74th St. Station, Interborough Rapid Transit C

1 Steam Piping Between High- and Low Pressure Turbine
2 Ring of Intermediate Blades for Low-Pressure Casing
3 Casting for One of the Spindle Ends
4 One of the Two Low Pressure Exhaust Openings
5 Bottom Half of Low-Pressure Casing
6 Low-Pressure Rotor.
7 High Press
8 Low Press
9 The Unit C









gh Rapid Transit Co., New York City.

7 High-Pressure Roto[r]
8 Low Pressure Side Assembled
9 The Unit Complete

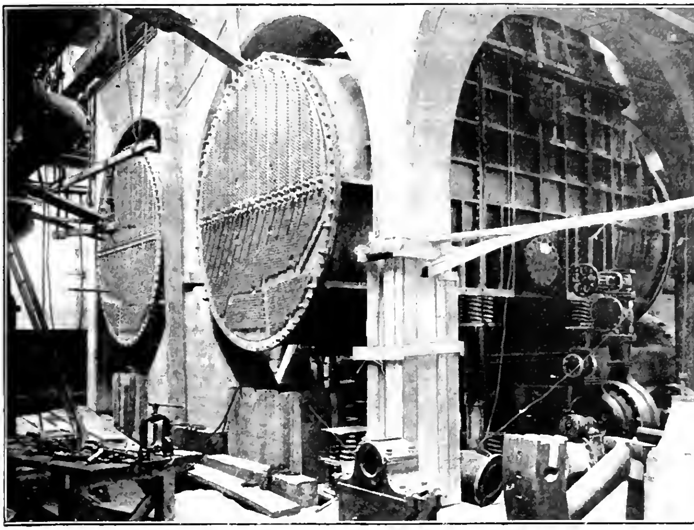


FIG. 1. NOTE THE STEAM PASSAGES IN THE TUBE BANK. CONDENSERS SUPPORTED ON SPRINGS MOUNTED ON SCREW JACKS

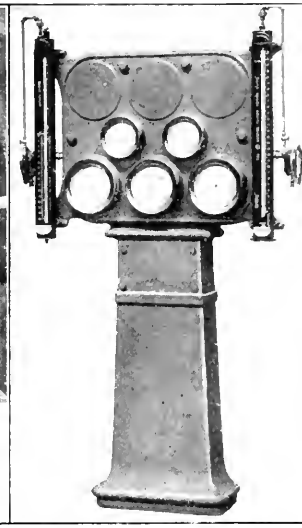


FIG. 2. THE GAGE BOARD FOR ONE OF THE 30,000-KW. TURBINES

As an indication of the advance in the economy of prime movers in recent years, the water rate of the new turbines for Seventy-Fourth Street is 30 per cent. better than for the engines they displace. For 30,000 kw. output per day of 24 hr., the turbine would save about $700 in coal alone.

WHY CROSS-COMPOUND TURBINES WERE SELECTED

The chief feature of these 30,000-kw. units is that they consist of two turbines, a high- and a low-pressure, erected side by side. Each half drives a generator, the high-pressure running 1500 r.p.m. and the low-pressure 750; the generators are tied together electrically. The turbine is of the reaction type throughout, no impulse wheel being used. The high-pressure element is single-flow, while the low-pressure is a double-flow machine. By dividing the unit into two unconnected parts the heat drop in each casing is also divided, which eliminates the distortions and the consequent severe stresses feared in large turbines having single casings. Most important, however, is the fact that by using two speeds the relations of steam velocities to blade speeds may be correctly met in both the high- and the low-pressure ends. The double-flow principle as applied to the low-pressure end also obviates the necessity of dummy pistons to balance the end thrust. The advantages of the cross-compound principle from the designers' standpoint have been so well brought out in an article written especially for POWER (Sept. 11, 1914, page 374) by Francis Hodgkinson,* designer of these units, that the reader is referred to it for further particulars.

BOILER PRESSURE INCREASED AFTER THIRTEEN YEARS' SERVICE

Until shortly before the installation of the new turbines, the Seventy-Fourth Street station furnished dry saturated steam to the engines at 160 lb. pressure. As the turbines are to have an exhaust pressure maintained at 97 per cent. vacuum (29.1 in., or 0.442 lb. absolute), it

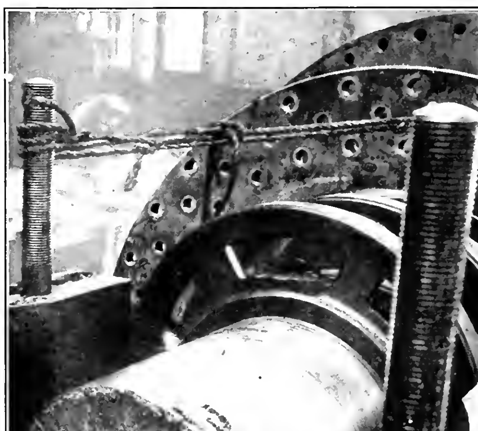


FIG. 3. THIS 32-IN. SHAFT, 16-IN. HOLE, CUT THROUGH IN THREE HOURS WITH OXYACETYLENE TORCH

was desired to obtain the advantages of a higher initial pressure than 160 lb. So the advisability of increasing it to 215 lb. was considered. The boilers had been designed

*Engineer, turbine department, Westinghouse Machine Co.

for 212 lb., with a factor of safety of 5, though never worked at that pressure, and had given thirteen years' service.

Pieces were cut from the steam drums and subjected to physical tests, which showed that the tensile strength is greater now than called for in the original specifications, 55,000 lb. having been specified, while the tests showed the present strength to be from 64,000 to 69,000 lb.

It is interesting to know that micrometer measurements of the plates show them to be from 0.01 to 0.02 in. thicker than the original specified dimensions.

After an investigation of all factors affecting safety, the owners and the Police Department decided that 215 lb. pressure was permissible, and a well-known insurance company assumed the risk at normal premium rates. In the calculations used to determine if 215 lb. would be an allowable working pressure, a factor of safety of 5 was used. All cast-iron mud drums were replaced with wrought steel, and steel fittings were put in to replace the cast-iron ones removed.

Changes Made in the Boiler Room

The need for higher rating of the boilers at greater economy was the deciding factor in the removal of the overfeed stokers and the installation of those of the underfeed type. With the former and the old engines 1150 kw. per stoker was the permissible maximum attainable, while with the latter and the new turbine 3750 kw., or 225 per cent. more, may be satisfactorily carried. The engineers for the purchaser state that the furnace efficiency for the underfeed stoker is 10 per cent. greater than for the overfeed in average running. The boilers will operate at 300 per cent. rating during the peaks, which come twice a day, each lasting about two hours.

As the boilers run at higher rating than formerly and, consequently, need more flue cross-sectional area, and partly because the feed temperature is high with all-steam auxiliaries, the economizers were removed. This enlarged the effective flue area enough to increase the natural draft from 0.7 to 1.25 in.

May Attempt to Cool Firebrick

It is the company's practice to set the firebrick in the furnace side walls from the grate to a point a little above the fire line, so that they may be renewed without disturbing the rest of the brick. This is true of all refractory material in contact with the fire. Heretofore, the same quality brick has been used below and above the fire line. But as the furnace and fuel-bed temperatures with the underfeed stokers will be higher than with the overfeed, it may be found expedient to use a better grade below the fire line. In the hope of using a low-grade, low-priced brick without experiencing the usual troubles, the experiment of embedding in each side wall a pipe carrying exhaust steam and air which will be discharged through small holes in the walls, is being tried out.

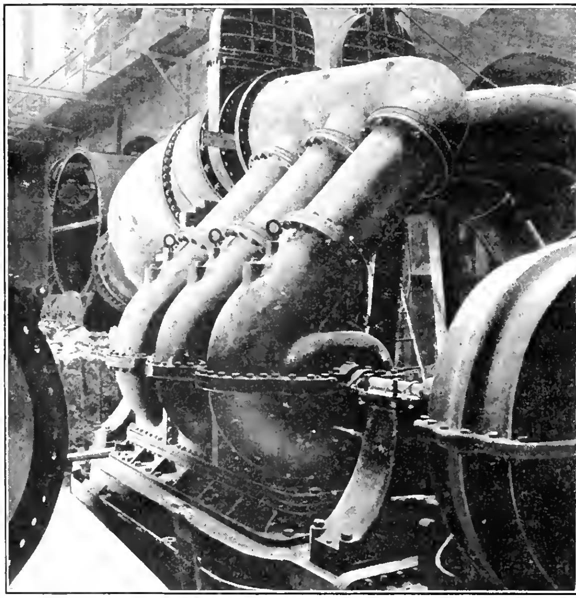


Fig. 4. One of the Circulating Water Pumps. Capacity 37,500 Gal. per Min.

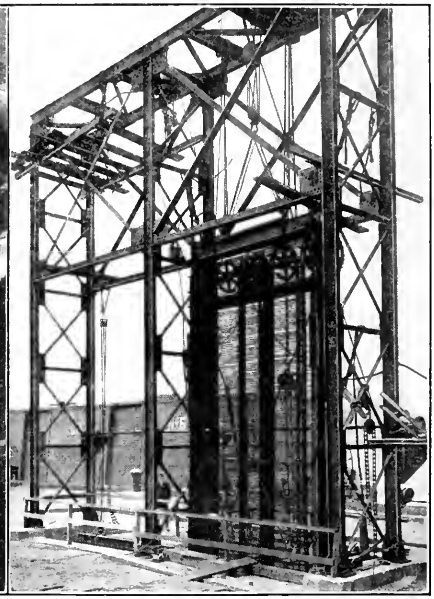


Fig. 5. Revolving Screens at the Condenser Water Intake Tunnel

Ratio Kilowatts to Boiler Horsepower

There are 70 boilers in the Seventy-Fourth Street station, six of 600 hp. each, the remainder, 520 hp. Eight of the latter were allowed for each of the 7500 kw. maximum capacity, reciprocating engines, giving a ratio of 1.8 kw. per rated boiler horsepower, installed capacity. It is worthy of note that eight of these boilers will be allowed for each 30,000-kw. turbine unit (see footnote under table, page 531), a ratio of 7.2 kw. per rated boiler horsepower installed, during peaks—the highest yet practiced, though it should be understood, of course, that an equivalent output is sometimes reached in other large plants during peaks. Unfortunately, at this time an economy,

Important Data, Seventy-Fourth St. Station

of the Interborough Rapid Transit Co., New York City, 1915

BOILERS

Total number of boilers	70
Heating surface, each, square feet—	
Six	6000
Sixty-four	5200
Number of boilers with superheaters*	32
Superheating surface per boiler, square feet	968
Grate surface per boiler, square feet	92
Number sq.ft. heating surface per sq.ft. grate surface	56.52
Number sq.ft. superheating surface per sq.ft. grate surface	10.52
Number sq.ft. heating surface per sq.ft. superheating surface	5.37
Heating surface per connected kilowatt, sq.ft.	1.386
Kilowatts per sq.ft. superheating surface	3.88
Kilowatts per sq.ft. grate surface	40.76
Kilowatts per boiler horsepower, installed capacity	7.21
Type of boilers	Babcock & Wilcox
Designed for 212 lb. pressure with factor of safety of	5
Present pressure, lb.	215

Boilers now have wrought-steel mud drums.

Boiler rating on peaks, 300 per cent.; between peak, about 100 to 150 per cent.

Underfeed stokers, seven-retort "Taylor," American Engineering Co.

Capacity of each stoker on peaks, kw.	3750
Chimneys—	
Number	4
Height, above lower grate, ft.	261
Diameter, inside, bottom, ft.	18
Diameter, inside, top, ft.	17
Boilers per chimney	16
Coal burned per sq.ft. grate, lb. per hr.—	
At normal rating	19
At maximum rating	60

*Only 32 boilers would be required and would be actually used to supply steam to three 30,000-kw. turbines, and of these 32 boilers it is anticipated that not less than four would be out of service continuously for repairs, overhauling, etc. The ratios are based on eight boilers per 30,000-kw. turbine, however.

TURBINES

Three 30,000-kw. "cross-compound" in present installation

Builders.....The Westinghouse Machine Co.

Speed: High-pressure, 1500 r.p.m.; low-pressure, 750 r.p.m.

Generators: Each, 15,000 kw., 3-phase, 25-cycle, 11,000 volts.

The two generators of each unit are tied together electrically.

Pressures: High-pressure initial, 200 lb.; initial pressure of low-pressure side, 12 lb. abs. at 16,000 kw.; 15 lb. abs. at 25,000 kw.; 19 lb. abs. at 30,000 kw.

Superheat at throttle, deg. F.	120
Vacuum, 97 per cent., or in inches of mercury	29.1

Performance guarantees: Operating conditions—200 lb. gage pressure, 120 deg. F. superheat and 29 in. vacuum (referred to a 30 in. barometer).

Net Kw. Load of Generator	Lb. of Steam per Kw.-Hr.	Rankine Cycle Efficiency, per Cent.
15,000	12.07	70.73
16,000	11.94	71.51
18,000	11.77	72.54
20,000	11.54	73.98
22,000	11 40	74.89
24,000	11.30	75.56
25,000	11.27	75.76
26,000	11.32	75.42
28,000	11.47	74.44
30,000	11.63	73.41

Most economical load, per cent. of max. 24-hr. load	83.3
Steam consumption of auxiliaries, per cent. main unit consumption—	
At most economical load	7.5
At full load	6.08
Power consumption of auxiliaries, per cent. main unit power, at full load	1.4
Blading, reaction; bronze throughout.	
Peripheral speed last rows low-pressure, ft. per sec.	400
Total weight, lb.	1,500,000
Weight per kilowatt, lb.	50
Heaviest piece to be lifted by crane, tons	78
Floor space, outside measurement, sq.ft. approx.	1600
Kilowatts per sq.ft. floor space	18.7

CONDENSERS

Builder	Henry R. Worthington Co.
Total tube surface, sq.ft.	50,000
Tubes, admiralty, 1 in. diam., 20 ft. 3⅜ in. long, 18 gage.	
Chief guarantee, 350,000 lb. steam condensed, water at 60 deg. F., 65,000 gal. water per min., maintaining 97 per cent. vacuum, 29.1 in. mercury.	
Tube area per kw., sq.ft.	1.67
Circulating pumps: Two per condenser, centrifugal; capacity each, gal. per min.	37,500
Type	Twin-shell, counter-current
Circulating-water pumping capacity per kw., gal. per hr.	150
Circulating-water pumping capacity per lb. steam condensed at consumption of 350,000 lb. per hr., pounds	107
On guarantee, 65,000 gal. per min., lb.	93
Diameter discharge pipe, in.	60
Cross-sectional area intake tunnel, sq.ft., approx.	138
Revolving, self-cleaning screens in intake.	
Maximum speed of tide in river, miles per hr., approx.	7
Area of each exhaust in condenser, sq.ft.	142
Steam velocity through each exhaust opening, ft. per sec.	227
Reciprocating dry vacuum pump, size, in.	14x39x30
Maker	Laidlaw-Dunn-Gordon Co.

MISCELLANEOUS

Turbine foundations of structural steel.	
Kilowatts per cu.yd. concrete in foundation	109
The foundations for the 7500-kw., max. 24-hr. rating engines each had 1500 cu.yd. of concrete.	
Anticipated station load, kw.	100,000
Total upward pressure of atmosphere on condenser when carrying 29 in. vac., lb.	290,566

or performance-at-different-load, curve of this turbine is not available for publication. It may be said, however, that it is liberally designed, for tests show that the consumption at full load is but little higher than that at the most economical load. Also, the turbines—three are to be installed for the present—will each easily carry 32,000 to 33,000 kw. with but a slight increase in steam consumption. The two now in service each carry this load nearly every morning.

Rubber Expansion Joints in Circulating Water Pipes

There are two condensers, one connected to each low-pressure exhaust outlet, and each is in three sections. The total tube surface is 50,000 sq.ft., in 4780 admiralty tubes, each 20 ft. 3⅜ in. long, 1 in. diameter and of 18 gage. The chief guarantee is 350,000 lb. steam condensed per hour with water at 60 deg. F., maintaining a vacuum of 97 per cent. (29.1 in., or 0.442 lb. absolute). The steam opening into each condenser is 142 sq.ft. in area. The openings in the bank of tubes to assure steam getting down around the bottom tubes are plainly shown in Fig. 1. Fig. 2 shows the gage board used.

The circulating-water pipes which supply both condensers are 60 in. diameter. A novel feature of construction is that there are no expansion joints between the turbine and condenser, each condenser being rigidly bolted to one of the exhaust flanges of the double-flow low-pressure turbine, there being provided a 36-in. connection with a copper expansion joint between the two condensers to maintain equilibrium of pressure. Hence, to provide for the expansion and contraction of the turbine under different operating conditions, it is necessary that the condensers be able to translate themselves with reference to each other. This necessitates quite flexible expansion joints between the circulating pipes and the water chambers. Copper expansion joints were first installed, but it was found that these held the condensers too rigidly and that they would not move with the expansion and contraction of the turbine. This difficulty was overcome by substituting rubber expansion joints. Inasmuch as the piping was in place, the joint must be so designed as to make use of the flanges and, to avoid special rubber work, must admit of using plain sheet rubber instead of a molded piece. The rubber is of a good grade and is five-ply, ½ in. thick and made up similar to belting.

Reference to Fig. 1 will show that the condensers are supported on heavy springs resting on screw jacks.

The air pump is of the reciprocating kind, being 14x39x30 in.

Fig. 4 shows one of the circulating pumps and Fig. 5 the revolving type of screen used at the intake.

Structural-Steel Supports

The economy in the use of concrete by using structural-steel supports for turbines over the old solid engine foundations is well demonstrated at Seventy-Fourth Street. The foundations for each of the 7500-kw. engine units required 1500 cu.yd., while for each 30,000-kw. turbine supported on structural steel, but 275 cu.yd. is needed and this chiefly to stiffen the supports against vibration. This is the heaviest turbine yet to be supported on structural steelwork. Although the tandem-compound, 30,000-kw. unit in Waterside No. 2 is so supported, it weighs less. The condenser support of the Waterside structural work has a system of spring beams to avoid the necessity of an expansion joint between the turbine exhaust opening and the condenser steam inlet.

In the removal of the large engines it was found expedient to cut the main shafts. These are each 37 in. diameter with a 16-in. hole, and by employing the oxy-acetylene torch it took but three hours to make a cut. See Fig. 3.

The Construction of the Turbine

The high-pressure side contains 38 rows of blades and differs but little from any other single-cylinder reaction turbine. The first 8 rows are mounted on a ring bolted to the casing. Following this are 19 rows mounted on a second and longer ring, or barrel. The remaining 11 rows are mounted directly on the casing. The rotor is 20 ft. 4⅝ in. long. The views on the insert give a good idea of the construction and size of one of the units.

The low-pressure turbine is double-flow. The casing is a simple shell affair except that it has some interesting reinforcing members. There is no blading mounted directly on the casing, but instead, it is all put on rings or barrels bolted to the casing. One of the intermediate-pressure rings for the low-pressure machine having the blading mounted is also shown in the insert.

The low-pressure rotor is made up chiefly of a hollow drum secured to two spindles, one at each end. The intermediate-pressure blades are mounted directly on the drum, and the low-pressure blades are put on rings which slip up over the spindles and are bolted fast. The spindle castings with the risers weigh 72,500 lb. each and are of steel. The rough ends without the risers weigh 38,500 lb. each.

A Cement for Leather

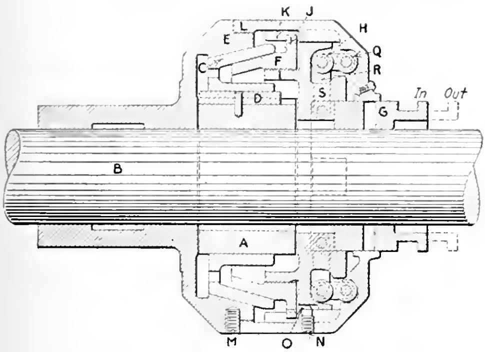
To prepare a cement suitable for leather belts or for fastening paper covering to pulleys, get the best cabinet maker's glue, in a quantity suitable to your requirements. A large quantity can be prepared if desired, for it will keep for some time after being mixed, if not permitted to dry out. Break the glue into pieces and put in a dish, with water just sufficient to cover it, and let stand twelve to fourteen hours, or until all of the water has been soaked up. Then melt the glue in a water or steam bath and add strong vinegar to thin it. It should then be evaporated until it will appear quite stringy from the stick or spoon used to stir it while hot.

A leather belt should be roughed or furred with sandpaper or a coarse file, which will make the joint stronger than if the leather were left smooth. If the leather is warmed before applying the glue, a better joint can be made. The laps should be scraped down to a thin edge and their length should be equal to the width of the belt. In making the joint, lay the belt on a board so that the parts come even, then fasten with a couple of nails through the leather a foot or more from the joint on each side, so that when one piece is raised from the other to apply the glue, it will fall back into the proper position. Apply the glue warm and pound the joint all over with a hammer and a block laid on the leather. A few tacks driven through the joint will assist in holding it together properly until the cement has set.

The same preparation can be used for fastening paper, cloth or split leather to a pulley to increase the driving power of the belt. If of iron, the pulley should be well cleaned by scraping and then washed with strong vinegar or a weak solution of sulphuric acid in water. Wipe dry and apply the paper, which has previously been covered with the hot glue. Two or three thicknesses of heavy straw paper will be found sufficient, and each layer should be firmly glued on. As soon as the first layer is applied and before the glue has had a chance to cool, roll or hammer the paper to bring it in contact with the pulley. Each layer should be treated in the same way. A belt should remain undisturbed for about five hours after the joint is made, before an attempt is made to use it. Three or four hours will be sufficient for the paper covering on the pulley.

Ideal Multi-Cone Clutch

This clutch, which is manufactured by the Akron Gear & Engineering Co., Akron, Ohio, might be termed a multi-disk cone clutch. In its design it retains the simplicity of the two-cone clutch, allows smooth engagement due to momentary slipping, and will release instantly. To avoid a too sudden engagement of the cones their face an-



Ideal Multi-Cone Clutch

gles are greater than those of the ordinary two-cone type, and the clutching force and pulling power so lost are more than compensated for by the addition of a third cone, which practically doubles the pulling power. The cones run in an oil bath which leaves a film between them and permits a slippage before being broken down by the pressure of coming into engagement. Owing to the face angles and the small unit pressure on them, as well as the oil bath, immediate disengagement occurs when the clutch is thrown out.

Means are provided to prevent the oil from escaping to the outer surfaces where it would be thrown off by centrifugal force. The horizontal pressure exerted by the throw in the mechanism is distributed equally around the circumference and does not distort the cones from a true circle.

When the clutch is out the throwing mechanism is still and centrifugal force cannot throw it in. When it is in centrifugal force cannot throw it out, but will tend rather to keep it in.

Referring to the illustration, the driving ring *A* is keyed to the shaft at *B*. The middle or driving cone *C* is driven by the ring *A* through two feathers *D;* both friction surfaces of this cone contain oil grooves. The driven cones *E* and *F* are brought into contact with *C* when the shifter sleeve *G* is pushed in, thus throwing the rollers *H* outward and forward against the adjustment ring *I*, which carries the cone *F* forward into contact with *C*, and the latter into contact with *E*. As the cones come into contact singly, too sudden clutching is prevented. The cone *F* is caused to revolve with *E* by means of the lugs *J* projecting outward on *F*, which lie between the lugs *K* on the casing *L*. The inner faces of the lugs *K* are turned true and hold the ring *I* central. The casing screws on the cone *E* and is locked by the screw *M*. The inner end of the locking screw *N* projects into one end of the numerous slots *O* in the outside periphery of the ring *I* and causes it to revolve within the casing *L*. The adjustment of the clutch is made by inserting the screw into one of the slots. The rollers *H* and *Q* and their pivot pins are large in diameter and in bearing area. The links *R* straddle the lugs *S*, the ends of which are raised slightly.

In throwing the clutch out, the rollers *H* strike the lugs *S* and pull the cone *F* forward, which gives the maximum clearance for the oil films between the cones. The throwing mechanism is powerful, the multiplication between the horizontal force on the shifter sleeve *G* and the pressure on the cone faces being approximately 100 to 1 on all sizes.

⁂

Large Buffalo Transformer Blower

An unusually large fan for cooling air-blast transformers has recently been installed at the Blue Island Power Station, Public Service Co. of Northern Illinois, by the Buffalo Forge Co., Buffalo, N. Y. The installation was made under the direction of Sargent & Lundy, engineers. It consists of a direct-connected blower handling continuously 40,000 cu.ft. of air per min. at 70 deg. F. and 29.92 in. bar., with a static increase in pressure of 2.6 in. water gage. The blower is directly connected to a 30-hp., 25-cycle, three-phase, 470 r.p.m. motor. Aside from the size of the unit, the interesting feature is the operating speed.

Most transformer cooling units are 20,000 cu.ft. per min. capacity or below, and although direct connection is desirable, it has heretofore involved prohibitive expense for the slow-speed motors necessary on larger units. The blower in this case is a turbo conoidal high-speed type,

Motor-Driven Fan of 40,000 Cu.Ft. of Air per Min.

such as has been used in connection with motor and steam-turbine-driven forced-draft units for underfeed-stoker work. Although the air pressures required for cooling air-blast transformers are considerably less than for stoker work, the speed of this fan is high enough to permit the use of a motor at a price which is not excessive. The fan is of the multiblade type with compact housing. The photograph shows the relative sizes of the fan and the motor. The fan has a static efficiency of 60 per cent. and requires 27 b.hp

Theoretical Efficiency of Heat Engines

By R. C. H. Heck

SYNOPSIS—Distinction between "actual" and "ideal" efficiencies, explanation of the Carnot efficiency and when it should be applied, also the error involved in using the "air standard" in connection with the Carnot efficiency in internal-combustion engines.

The term "heat engine" covers all forms of apparatus for converting heat into work, and the only practical way of making this conversion is by means of an expansive medium which may be either a liquid (alternately vaporized and condensed) or a dry gas mixture. In judging the performance of a heat engine there are three efficiencies to be considered—actual, ideal and relative.

Actual efficiency is the ratio of the heat converted into work (or work output measured in heat units) to the heat supplied, these quantities being determined by test or experiment. No heat engine converts into work more than a minor portion of the heat energy which it receives. This is due largely to the inherent nature of the heat-engine process and in lesser degree to imperfections of actual material and operations. For any set of limiting conditions it is possible to calculate, from thermodynamic theory, the efficiency of an ideal heat engine, free from all secondary imperfections.

This ideal efficiency is the proper basis for judgment of actual performance. Thus, a conversion ratio of 0.24 for the best steam turbine may seem a poor showing, but when theory determines that an ideal apparatus under the same conditions could convert only 0.34 of the heat received, it appears that the real engine is doing about 70 per cent. as well as the ideally perfect one. In medium to very good practice this relative efficiency, the ratio of actual to ideal, ranges from 50 to 75 per cent.

The Carnot Engine

Any heat engine operates by receiving heat at high temperature, converting a part of it into work, and rejecting the remainder as heat at low temperature. The simplest possible scheme, thermally, is that of the ideal Carnot engine, in which the temperatures of heat reception and heat rejection are constant throughout the respective operations, and in which there are no losses by radiation, cylinder-wall action or machine friction.

The temperature-entropy diagram in Fig. 1 represents the working of the Carnot cycle. The expansive medium is confined in a suitable cylinder with a piston, and at A it has the upper temperature and a high pressure. Receiving heat at the constant absolute temperature T_1, it changes to state B by isothermal expansion. The quantity of heat Q_1 received is represented by the area $ABFEA$: which has the width $EF = Q_1 \div T_1$. This horizontal distance EF is known as the "difference in entropy" and will be represented by N. Applied to steam, EA represents the absolute temperature corresponding to the given pressure: the condition at A would be hot water at

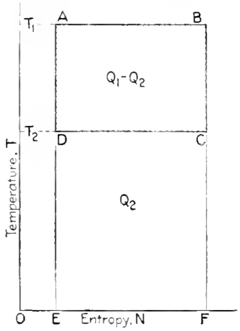


Fig. 1

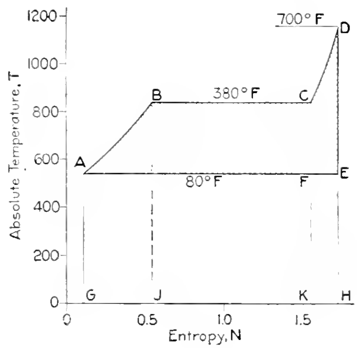


Fig. 2

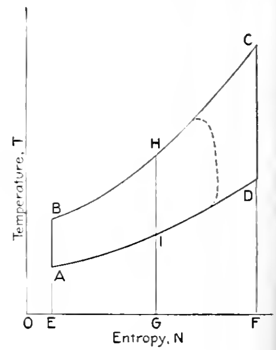


Fig. 3

this temperature, and the area $ABFEA$ would represent the latent heat necessary to change the water into dry saturated steam, which condition is represented at B; finally, AB ($= EF = N$) is the distance necessary to make the area $ABEFA$ proportional to the latent heat at temperature T_1.

At B in Fig. 1 the supply of heat is shut off and expansion continues in the perfectly nonconducting cylinder until the temperature is lowered to T_2 at C. The drop in temperature is due to the expenditure of heat energy in the work of expansion; but since no energy is transferred in thermal form, there is no change of entropy. A no-heat-transfer operation is called adiabatic.

From C to D the medium is compressed isothermally (at constant temperature) at T_2, surrendering the heat $Q_2 = NT_2 =$ area $DCFED$, and adiabatic compression from D up A completes the cycle. With a heat input Q_1 and heat, $Q_1 - Q_2$, converted, the efficiency is

$$E = \frac{Q_1 - Q_2}{Q_1} \qquad (1)$$

which is a general expression applicable to all heat engines. Here $Q_1 = NT_1$ and $Q_2 = NT_2$, so that the efficiency of this cycle may also be expressed by

$$E = \frac{T_1 - T_2}{T_1} = \frac{t_1 - t_2}{t_1 + 460} \qquad (2)$$

in which t_1 and t_2 are the Fahrenheit temperatures corresponding to the absolute temperatures T_1 and T_2.

Sometimes this Carnot efficiency is used erroneously as a standard when it does not fit the conditions of the actual plant. A notable example is found in the issue of June 9 last, in the abstract of a lecture by F. G. Gasche, on "Power for Steel Mills." For a steam turbine using steam superheated to 700 deg. F. and with exhaust at 80 deg., the ideal efficiency is there computed as

$$E = \frac{700 - 80}{700 + 460} = \frac{620}{1160} = 0.535$$

As a matter of fact, this result is about 60 per cent. in excess of the correct value.

Ideal Steam Cycle

Fig. 2 shows the ideal cycle for the steam engine or turbine, within the limits just named and with the additional datum that vaporization shall take place at 380 deg., or that the boiler pressure shall be about 195 lb. absolute. The cycle begins at A with 1 lb. of feed water at exhaust temperature pumped into the boiler. Curve AB represents the heating of the water up to the boiling point of 380 deg. F., or 840 deg. absolute; it receives heat and acquires entropy as the temperature rises. The horizontal line BC represents the isothermal, or constant-temperature, operation of vaporization. At C the steam is dry saturated, and its superheating from 380 to 700 deg. is represented by curve CD. At D the total heat of the steam is 1370 B.t.u., and the heat imparted, beginning with water at 80 deg. F. (540 absolute), is 1322 B.t.u., represented by area $GABCDHG$.

The operation $ABCD$ is performed in the boiler, and we assume that the steam is carried over to the engine or turbine without loss of heat by radiation or of pressure by pipe resistance. Then adiabatic expansion, whether in the ideal non-conducting cylinder or in the formation and utilization of a perfect steam jet, lowers it to state E. Abstraction, of heat in the condenser, of the exhaust heat Q_2 (area $EAGHE$ = 879 B.t.u.), is represented by the isothermal line EA. The ideal efficiency is now, as against the 0.535 previously figured, only

$$E = \frac{Q_1 - Q_2}{Q_1} = \frac{1322 - 879}{1322} = \frac{443}{1322} = 0.335$$

The diagram shows clearly the error involved in using for T_1 in the Carnot expression, equation (2), the highest temperature reached by the medium, instead of making it the temperature of heat reception. When the latter temperature varies, as here, it might be replaced by a mean value of equivalent effect, although that is not the direct or the better way of calculating E. Just to see how nearly the vaporization temperature of 380 deg. would come to serving as such an effective average value, try it in equation (2), from which will be found

$$E = \frac{380 - 80}{380 + 460} = \frac{300}{840} = 0.357$$

Evidently $t_1 = 380$, or $T_1 = 840$, is a little too high for this purpose.

Because so much of its heat reception is at T_1 and all of its heat rejection at T_2, the steam cycle is fairly near the Carnot in general form. The practical reason for this is that the constant-pressure operations of vaporization and condensation are characterized also by constant temperature. But in no scheme of gas-engine working do isothermal operations find place.

Otto Gas-Engine Cycle

Consider the Otto cycle outlined in Fig. 3. The operation begins at A with a charge of gas mixture under atmospheric pressure and of a little higher than atmospheric temperature. Line AB shows adiabatic compression, followed by the reception, at practically constant volume and with a rapidly rising temperature, of the heat of combustion. This heating along curve BC is followed by the ideal adiabatic expansion CD, and exhaust is taken to be equivalent to constant-volume cooling along curve DA. The actual performance, in an actively conducting cylinder and with combustion more or less retarded, is somewhat of the form sketched by the dotted line.

It has been usual, for a simple calculation of theoretical efficiency, to assume that the gas mixture is practically the same as air in properties and that its specific heat is constant, not rising with temperature. Under the latter assumption the ratio of low to high temperature is the same on any ordinate in Fig. 3, whether at the extreme lines BE and CF or on any vertical HG. If then

$$\frac{T_A}{T_B} = \frac{T_D}{T_C} = \frac{T_I}{T_H}, \textit{ etc.}$$

it is evident that the conversion area $ABCDA$ will be to total heat area $EBCFE$ as $T_B - T_A$ is to T_B, or that the Carnot ratio will apply if the limiting temperatures of either adiabatic are used in place of certain constant temperatures.

The principal purpose in writing this article has been to lay before the readers the fact, to be found only in the more recent textbooks, that the use of this simple air standard involves a large error. Computed results from a typical example are laid out in Figs. 5 and 6, where the dotted diagrams marked a are for ideal air and the full-line diagrams b represent the behavior of an actual gas mixture.

The medium selected in the example is a blast-furnace gas with a moderate excess of air in the combustible mixture. Its heat value is such that perfect combustion generates just 1000 B.t.u. per pound of mixture, the diagrams being drawn for that quantity. The specific heat rises with the temperature according to the constant-rate law shown by straight lines Nos. 2 and 3 in Fig. 4, of which No. 2 is for the original mixture and No. 3 for the products of combustion; line No. 1 shows the uniform value, C_v = 0.169, for the ideal air medium.

One main determinant is the pressure of 175 lb. absolute at the end of compression in Fig. 5 (points B and B'). This and the initial atmospheric pressure and an assumed temperature of 80 deg. F., or 540 deg. absolute, at A and A' are the only conditions common to the two cases, although the compression curves AB and $A'B'$ are very much alike. The greatest difference is seen in the temperature rise from B to C and B' to C', with the resulting expansion lines CD and $C'D'$. Curve c is a rough guess at the probable actual indicator diagram.

Of course, such a tremendous rise of temperature as that which carries C' up to more than 7000 deg. in Fig. 6 and the corresponding pressure to 1100 lb. in Fig. 5 is physically impossible. Even the more reasonable height of point C runs into a region where dissociation is probably a potent influence and where our knowledge of specific heat is vague. But disregarding the fact that the conditions of diagram a are largely imaginary and those of b in some degree doubtful, the results of calculation may be summed up as follows:

In diagram a, Fig. 6, the four corner temperatures are: $T_A = 540$ deg., $T_B = 1104$ deg., $T_C = 7021$ deg., and $T_D = 3434$ deg. Then the efficiency is

$$E = \frac{1104 - 540}{1104} = \frac{7021 - 3434}{7021} = 0.511$$

In diagram b the corresponding temperatures are: $T_A = 540$ deg., $T_B = 1092$ deg., $T_C = 4818$ deg., and $T_D = 3315$ deg. With these the Carnot ratios at the limiting ordinates BA and CD are very different, being

$$\frac{1092 - 540}{1092} = 0.505 \quad \text{and} \quad \frac{4818 - 3315}{4818} = 0.312$$

A notable effect of higher specific heat is the relatively smaller vertical width of the effective area $ABCDA$, as

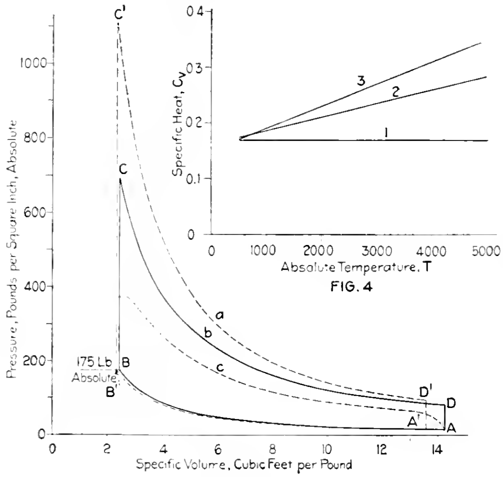


FIG. 5

compared with $A'B'C'D'A'$ (Fig. 5). Efficiency is found, however, not from temperatures but from heat quantities, as referred to in the method of equation (1). Along curve BC (Fig. 6) the heat received from combustion is 1000 B.t.u., while that rejected along DA is 632 B.t.u.; then the efficiency is

$$E = \frac{1000 - 632}{1000} = 0.368$$

The physical data for a calculation such as is represented by diagrams b, Figs. 5 and 6, are not complete in full accuracy. The methods of calculation are more directly related to Fig. 5, involving data as to pressure, volume and specific heat; and the heat converted, 368 B.t.u., is strictly equivalent to the work area $ABCDA$ in Fig. 5. When entropy is calculated, rather as a secondary quantity, a discrepancy develops; the diagram in Fig. 6 failing to close by the amount A_1A.

USEFULNESS OF IDEAL EFFICIENCY

Ideal efficiency, or the performance and output of the Rankine cycle represented by Fig. 2, is regularly used as a standard of comparison for steam action; but with internal-combustion engines it is little used. The simple air standard is so much in error as to be worthless, and the more correct method requires complicated and difficult calculations. For one thing, it must start in each case with the proportions of the particular gas mixture, upon which the average fundamental physical properties of the medium are dependent; and even with the simple straight-line law for variation of specific heat with temperature (itself probably no more than an approximation), the change of temperature in an adiabatic operation can be found only by a troublesome trial solution. Merely to state and outline the calculations for Figs. 5 and 6, including a number of intermediate points on each curve, would take considerable space, with no explanations or proofs; and while the direct calculation of ideal efficiency alone is much shorter, it is yet rather beyond the scope of ordinary use. Therefore, gas-power engineers will probably continue to be satisfied with actual efficiency as a measure of performance.

The really important result from the example here set

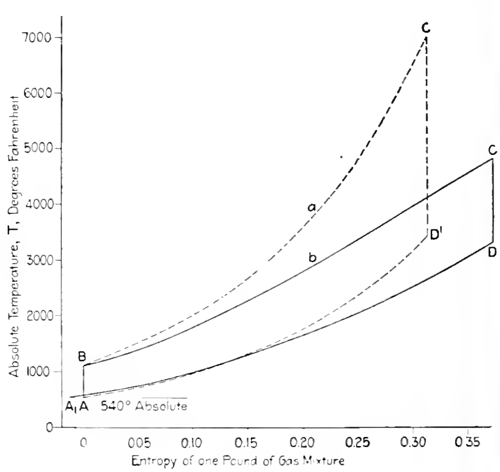


FIG. 6

forth is the relatively low value, 0.37, for true ideal efficiency, as against 0.51 under the assumption of constant specific heat. Considering the intense action of the cylinder walls in a gas engine, the relative efficiency is not likely to be over 0.6. Applying this to 0.37, we get a probable actual value of 0.22, and see that so far as the conversion of the heat supplied to it is concerned, an engine using blast-furnace gas is much in the same class with good steam engines and turbines. This does not, of course, deny the great economy of using such gas directly in the engine instead of burning it under steam boilers.

*

Coal for Coke—In the last five years the coal used in metallurgical coke manufacture has averaged around 65,577,000 tons, yielding 43,983,000 tons of coke, valued at $111,736,000. Of this total, 14,767,000 tons were used in byproduct coke ovens, yielding, besides the coke 54,491,000 cubic feet of gas 94,306,000 gallons of tar, and $9,190,000 worth of ammonia. When it is considered that every year approximately four times these enormous totals of byproducts are absolutely wasted through the use of non-byproduct ovens, the vital importance to the country of a general use of the modern, scientific byproduct ovens will be appreciated.—"Journal of the Franklin Institute."

A Forty-Million-Revolution Compressor-Valve Test

In the endeavor to test to destruction one of the feather valves now being used by the Laidlaw-Dunn-Gordon plant of the International Steam Pump Co., for air and gas compressors, the builders fitted a small vertical compressor with one of the standard-type feather valves and with an annular valve of the so called low-lift, plate type, the latter being of standard German manu-

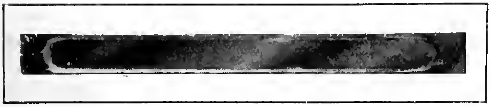


FIG. 1. SEATING SURFACE OF FEATHER VALVE. THE LIGHTER PORTION SHOWS THE SURFACE AFTER FORTY MILLION REVOLUTIONS OF THE PUMP

facture. The valves were used alternately for intake and discharge. The compressor was operated at a speed of 560 r.p.m. against a pressure of 40 lb. during each working day of ten hours, for a period of six months, aggregating in that time something over forty million revolutions. During this period three of the annular valves gave out, while the original feather valve at the end of the period had gone no further than to perfect its seat. Fig. 1 is a photograph of one of the blades used, the lighter portion indicating the polished surface of the seating area.

Forty million revolutions represents about a year's operation at 225 r.p.m. The speed of 560 r.p.m. should, on the basis of ordinarily accepted practice, result in destructive action four times as fast as a speed of 280 revolutions, which represents about the limit of commercial practice at present. The builders claim, therefore, that this run of forty million revolutions at 560 r.p.m. is the equivalent of at least four years' normal running, and the valves, judging from their appearance, had not even begun to deteriorate.

The valve on which this test was made is designated by its builders as the Laidlaw feather valve (patented),

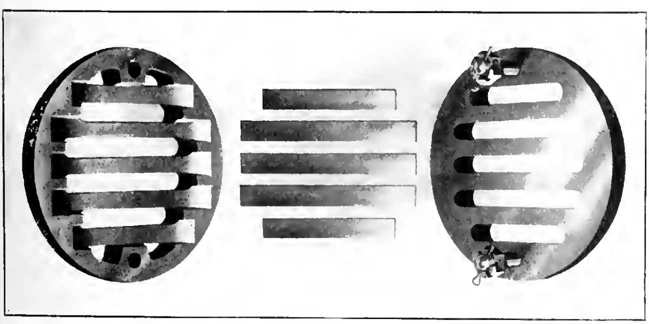


FIG. 2. THREE ELEMENTS COMPRISE THE FEATHER VALVE

Fig. 2. The complete contrivance consists of three elements only. The valves proper are strips of light flexible flat steel stock similar in appearance to ordinary clock-spring stock, but more flexible and of a much lower temper. These strips, which in the average valve are about ½ in. wide and vary in length from 4 to 12 in., seat on the ground face of a slotted casting, the slots being slightly smaller than the strips. The valves are not held rigidly at any point, but are restrained in movement by a curved guard with slots staggered to the slots in the seat, the spaces between being milled out on a curve against which the valve bows up when in an open

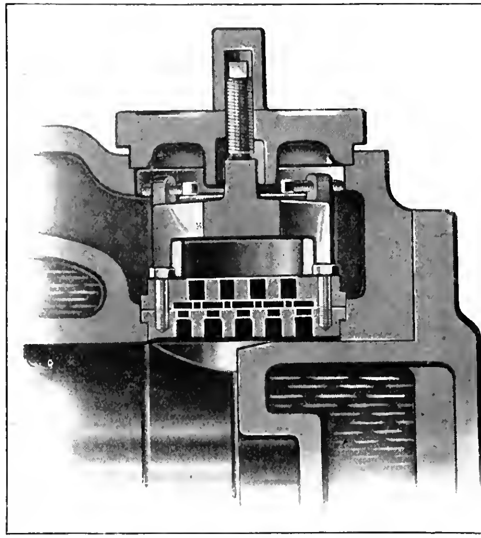


FIG. 3. DETAILS OF THE VALVE ASSEMBLED

position, to allow the passage of air. The ports are shown in Fig. 3.

The guard is lightly bolted to the seat, the strips being thus held between, free to bend up and down in the middle, their ends always remaining in contact with the seat, giving a breathing rather than a slapping action. The movement of the valve is controlled by the air flow, the valves themselves having negligible spring action, the best results being obtained with the highest flexibility. They are so light as to respond instantly to change in air flow, their flexibility not only permitting air to flow through them with a minimum of spring resistance, but also resulting, with the reversal of air travel, in almost perfect contact with the seat. The notable feature of this valve as compared with the older type of poppet or with the newer type of low-lift plate valve, is the fact that it seats not by impact of the entire valve, but by increasing contact from the ends to the center. This characteristic, in combination with extreme lightness and flexibility, not only results in the marked durability demonstrated by the test carried out, but also permits a lift area greatly in excess of that obtainable with the annular low-lift type, seating by impact. The valve as applied to a compressor is shown in Fig. 4.

In efficiency of performance the valve shows actual measured volumetric efficiency approaching within less

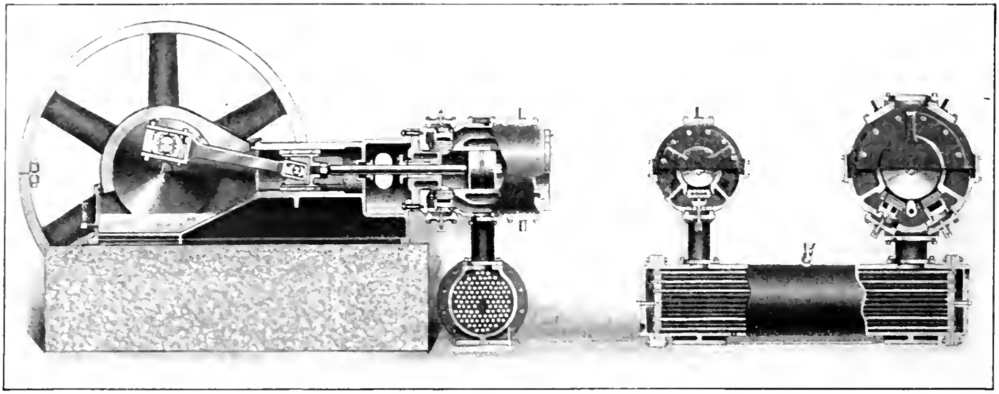


Fig. 1. Feather Valves Applied to an Air Compressor

than 1 per cent. of the efficiency indicated by a diagram, which latter indicated efficiency shows only the reëxpansion loss from clearance. This close approach of the actual to the indicated efficiency is a significant check on the valve performance, inasmuch as the clearance reëxpansion indicated by the card, and which is inevitable in any practicable air compressor, is not an economical loss, the energy return of the clearance reëxpansion being practically identical with the energy absorbed in its compression.

Contact seating, in addition to contributing to a high degree of durability and permitting the high lift which gives the valve its exceptional efficiency, also accounts for its remarkably quiet action.

Extreme simplicity of makeup permits the valve to be made reversible as regards seat and guard, so that the same valve can be used in its cylinder optionally as an intake or a discharge valve, the construction of both being identical and their function being determined only by the relation of the seat to the cylinder bore.

Nugent's Indicator Reducing Motion

A simple indicator reducing motion has been designed recently by Wm. W. Nugent & Co., of Chicago. It may be attached to any Nugent telescopic crosshead-pin oiling device or to a special stand on the floor. The former

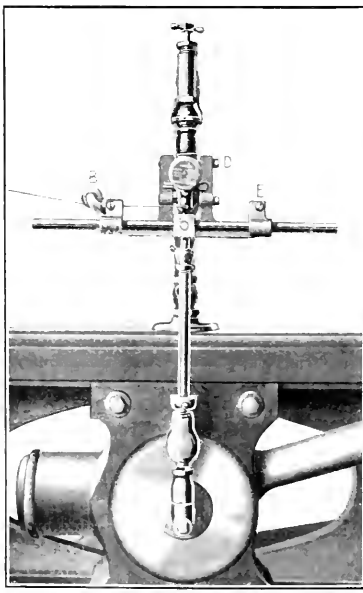


Fig. 1. Nugent Reducing Motion Attached to Crosshead-Pin Oiling Device

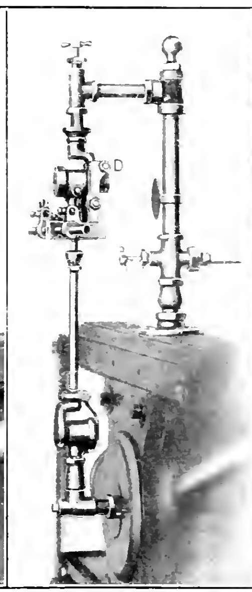


Fig. 2. Side View of Reducing Motion and Oiling Device

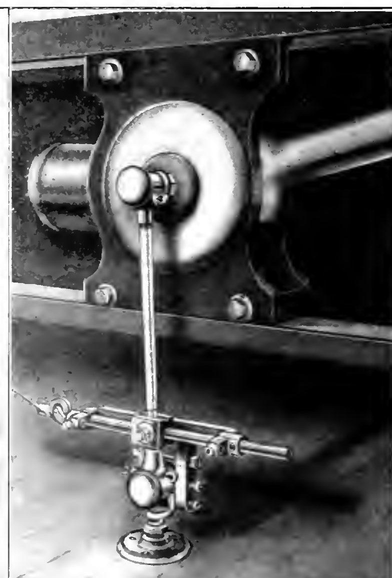


Fig. 3. Reducing Motion Supported by Stand Secured to the Floor

method of attachment is shown in Figs. 1 and 2 and the floor stand in Fig. 3. Either is mounted at the center of the stroke.

As shown in the first two illustrations, the reducing motion consists of a forked member which straddles and is clamped to the oiling device mounted on the top guide to the crosshead. The forked member just referred to supports two horizontal tubular guides for an oscillating block which reproduces on a smaller scale the motion of the piston. The block is moved back and forth by the telescopic tube of the oiling device. A pin that is free to turn passes horizontally through the block. The former is bored radially to allow the telescopic tube to pass through.

A given point on the tube naturally moves in the arc of a circle, but the arrangement allows the block to travel horizontally, as it may slide along the tube away from or toward the fulcrum, as it moves either side of the central position. As the pin is free to turn, there is no binding action on the tube. The cord is attached to this same pin and on its way to the indicator passes through a swivel guide pulley. The device accurately reproduces the motion of the piston and can be easily attached to or removed from the supporting element.

A Question Puzzling to Some

Many of our very practical engineers do not understand the reason for the greater efficiency or economy of a compound condensing over a simple condensing engine. The prevailing idea seems to be that power and efficiency are derived only from a greater number of cylinders. The principal difference in the two engines is entirely overlooked—the difference in the loss of heat through cylinder condensation; otherwise the greater number of cylinders would be of no advantage, but a disadvantage.

Consider the diagram of a 300-hp. simple condensing engine, admitting steam at a pressure of 200 lb. absolute and a temperature of 287.2 deg. F. and expanding down to 1 lb. absolute and 102.9 deg. F., thus losing 284.4 deg. F.; or, in other words, admitting steam at the high temperature of 387.3 deg. F. into a cylinder which has been cooled to some extent by the expanded steam at 102.9 deg. F., thus condensing and losing a large percentage of the incoming steam in reheating the cylinder.

With a compound engine with steam at the same pressure and temperature, and the high-pressure cylinder expanding it down to 27 lb. absolute at 245.1 deg. F., the temperature difference between the admission and exhaust is only 142.2 deg. F. This exhaust from the high-pressure cylinder is admitted into the low-pressure cylinder at practically the same pressure and temperature, and expanding in its turn to 1 lb. absolute and 102.9 deg. This makes a difference of 142.2 deg., the same difference of temperature between the admission and exhaust in the high- and low-pressure cylinders.

By having two cylinders, as in the compound engine, the extreme difference in temperature met with at admission in each cylinder is reduced.

Rate of Combustion is the amount of fuel burned per hour per square foot of grate surface. It varies from about 5 lb. in small furnaces to 100 in large furnaces under forced draft. The ordinary rate for anthracite is from 5 to 15 lb. and for bituminous coal 5 to 25 lb.; in locomotives, from 45 to 90 lb.

Just for Fun

A foreigner who spoke very little English was second fireman in a plant of eight 150-hp. horizontal return-tubular boilers. The so called "Hunkie" was told one day to take one of the boilers out of service for cleaning and repairs. He shut the header valve all right, and when the steam pressure had fallen to 60 lb. he went to blow down the boiler, but the blowoff pipe was completely stopped up. He then took the blind flange off the cross on the end of the pipe and commenced poking at the obstruction with a rod while there was still 60 lb. pressure on the boiler. Somebody caught him before he completed the "suicide act."—*F. F. Jorgensen, Gillespie, Ill.*

In a plant where I was employed a man who was interested in the plant and was supposed to understand electricity came in one evening during the peak-load period. There were two machines, and No. 1 was permanently connected up, but No. 2 was only temporarily connected, and in such a manner that one main circuit-breaker served both machines, although only one could be run at a time. The feeder switches were all of the quick-break type. These switches were something new to the gentleman, and I showed him how they worked, and remarked that the large one was the main switch for the idle machine. At this time I turned to a storage-battery panel, and bang went the circuit-breaker and everything went out. He had simply tried that large quick-break switch, but when things were in order again he remarked: "I guess it is a good idea to leave things alone that we are not acquainted with."

In this same plant we were required to take ground readings from all of the circuits once a day, before the evening load came on. The "boss" had a habit of coming in frequently and pulling out and putting in switches and watching the effect on the ground indicator. On one occasion he came in before I had tried the circuits and proceeded as usual. It happened that I went over to the engine while he was engaged with the switches and coincident with my move he threw in a switch which had been open, and started a commotion. I was innocent of any connection with the short-circuit, which was on that line, but circumstantial evidence was against me. Our "friendly relations" were not "strained" at all, but the "boss" sort of lost interest in grounds.—*H. L. Strong, Yarmouthville, Me.*

The fellow who painted the commutator has nothing on a painting stunt pulled off by one of my men last fall. I decided to give the machinery a coat of paint. The boys prided themselves on the appearance of the lagging, valve-gear and especially the well polished cylinder head of a Corliss engine. One afternoon all the painting was completed with the exception of an oil guard on this engine. The middle-watch man was told not to run the machine that night, but to finish the painting job.

The following morning I found our nice lagging, cylinder head, bonnets and valve-gear, including the sole plate and dashpots, all painted green, and it had begun to run and then baked. The color of the atmosphere was "some variegated" while we were scraping paint.—*E. B. Mertens, Milwaukee, Wis.*

Automatic Electric Elevator Dispatcher

By Norman G. Meade

Dispatching of passenger elevators in large office buildings has received considerable attention recently, and it has been the aim to obviate the human element as far as possible. The engineering staff of the Insurance Exchange Building, Chicago, has designed and installed an automatic electric dispatcher which times the starting of the elevators from both the bottom and the top floors. This building is a modern 18-story office structure covering half a city block and is equipped with sixteen electric passenger elevators arranged in four banks on four sides of the building.

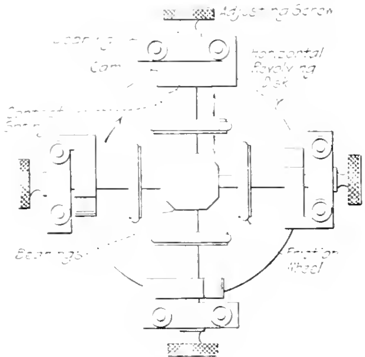


Fig. 1. Plan of Dispatcher

These elevators are of the Otis traction type, operated by 25-hp., 220-volt direct-current motors controlled by Otis type MF4 controllers. Eight operate as express cars and eight as locals. The floor signals for the former normally do not operate below the twelfth floor, but on occasions such as Sundays and holidays, a switching arrangement is provided which throws in the signals for all floors. The automatic dispatcher presents several novel features and signals the starting of the elevators independently of the hall men, who merely direct persons to their desired destination in the building.

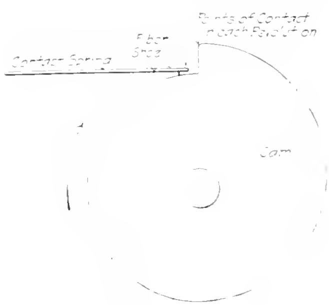


Fig. 2. Cam and Spring Contact

There is a bell located at the top and at the bottom of each bank of elevators, operated by the dispatcher. This bell is adjustable so that the timing of the cars may range from 20 to 60 sec. A 220-volt to 15-volt motor-generator set, with an auxiliary storage battery, furnishes energy for the dispatcher.

Fig. 1 is a plan view of the dispatcher, which consists essentially of a horizontal revolving disk operated through reducing gears by a $1/6$-hp. motor at a constant speed. Four vertical columns attached to the slate base support four independent hollow shafts to which are attached friction wheels and cams; a contact spring rests on each cam, but is normally out of electrical contact except once in each revolution. The horizontal shafts are hollow and inclose a threaded rod which engages with a central projection from the friction wheel that passes through a slot in the shaft. Hence, the position of the friction wheel on the shaft can be varied by turning the adjusting screw one way or the other. Moving the friction wheel toward the center of the revolving disk decreases the speed and moving it toward the outer edge increases it.

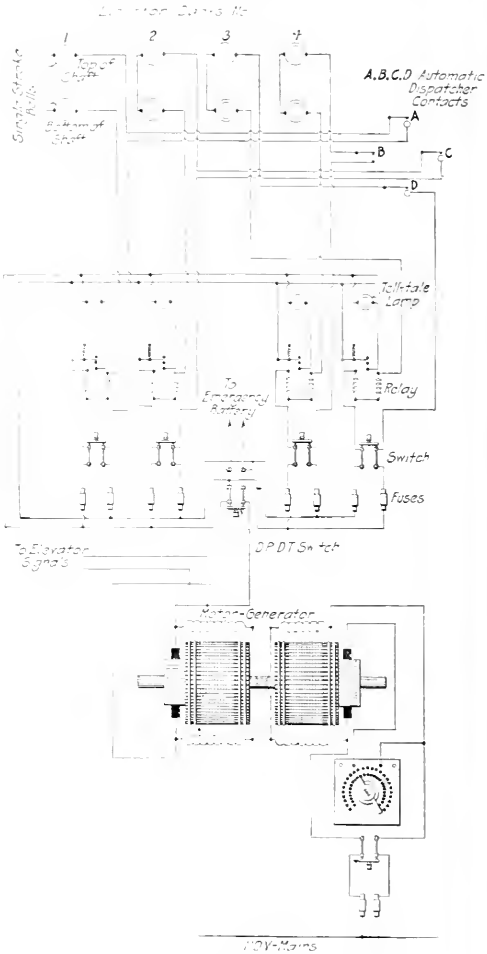


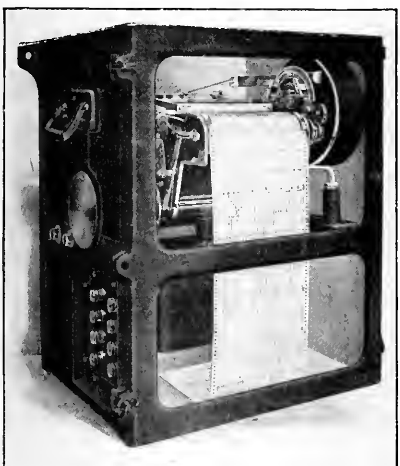
Fig. 3. Wiring Diagram of System

Details of the cam and spring-contact arrangement are shown in Fig. 2. The former is insulated from the latter by a fiber shoe, except when the spring escapes over the lip of the cam, and an open circuit normally exists. Fig. 3 is a wiring diagram of the motor-generator set and the dispatcher with its switchboard. The double-pole, double-throw switch in the center of the board is for disconnecting the motor-generator set and connecting the batteries in case of emergency. A relay is connected in the generator circuit and in case of failure of the latter, releases its armature which closes a local circuit and lights a telltale lamp, warning the attendant.

The dispatcher equipment on the board consists f four sets of fuses, four double-pole switches, four telltale lamps, and four relays—one o tfit for each bank of elevators. As the horizontal shafts of the dispatcher revolve, contact is made each revolution as the contact springs slip over the lips of the cams, closing the circuit through the relay coils and the single-stroke bells which are connected in series. The relay draws down its armature and closes the circuit through the telltale lamp, which lights, indicating that the signal has been given. Cars start in order in each bank of elevators, one after the other at the signal, and return from the top in the same order on receiving the signal.

Recording Pyrometer

The recording pyrometer shown is of a new type developed by the Wilson-Maeulen Co., 1 East Forty-Second St., New York City, and is to be marketed under the trade name of "Tapalog."



"TAPALOG" AUTOGRAPHIC PYROMETER

A special feature of this instrument is that the carriage containing the record paper, typewriter ribbon and other recording mechanism is pivoted to drop away from the galvanometer so that the paper and ribbon can be changed without danger of injuring the galvanometer.

The record is taken on the under side of the strip. The tracing paper used is visible from both sides and the speed of the record is 1 in. an hour. A dot is made every 12 seconds, and during the intervening period the pointer is free to swing to its true position.

The depressing member which makes the dot is operated by a three-cell dry battery; the clock merely shows the time. The indicating scale is mounted on the front of a chopper bar that is pulled down by an electromagnet, with a blow to make the record, and this bar is over-counterbalanced so that it tends to rise quickly after the downward stroke, at the bottom of which the electromagnetic circuit is opened.

The Tapalog will take a single record of one temperature in one color, but it is generally furnished with an automatic switch which, every minute and a half, switches the Tapalog from one thermocouple to the next and brings another portion of the multi-color typewriter ribbon under the pointer, so that the different records are taken in as many as four distinctive colors.

Multiple recording is important, for instance, in a large furnace where thermocouples are inserted at different points: the r cords, all being on one sheet, show definitely whether the furnace is evenly heated or just what the degree of uneven heating may be—the whole graphically set forth in a multiple record. The ribbon that passes under the record paper is made in the form of an endless belt so that it is not necessary to employ any mechanism to reverse the direction of travel.

This pyrometer may be located a long distance from the furnace, and to overcome shrinkage it is provided throughout with bakelite disks, washers, plates and other working parts.

Steam-Turbine Rolling-Mill Drive

The rolling mill has been one of the last stands of the large reciprocating engine. The Carpenter Steel Co., of Reading, Penn., has, however, recently installed a low-pressure steam turbine for driving two stands of 18-in. three-high mills. The turbine is of the De Laval multi-stage impulse type, in nine stages. It runs at 5000 r.p.m., and the speed is reduced by double helical involute gears, first to 600 and then to 100 r.p.m. The Jahns governor, with which it is supplied, may be adjusted while the machine is in operation, to vary the speed from 100 to 70 r.p.m. on the mill shaft.

The turbine will operate normally with 3 lb. gage pressure at the turbine throttle, and with 3 in. absolute pressure in the turbine wheel case at the exhaust end, under which conditions it will carry 350 hp. at the speeds mentioned and require not more than 26 lb. of steam per hour per brake horsepower, the power being measured at the end of the second gear reduction. It may be run low-pressure condensing, mixed-pressure condensing, high-pressure condensing, and high-pressure noncondensing.

With 120 lb. pressure at the throttle and 3 in. absolute pressure in the turbine wheel case, it is guaranteed not to require more than 17½ lb. of steam per brake horsepower-hour. As a mixed-pressure turbine, with the same pressure conditions, it will carry 600 b.hp. continuously, and is also designed to carry the full load of 600 hp. on the high-pressure steam alone, under which condition it is guaranteed to take not more than 15.7 lb. of steam per brake horsepower-hour.

American Cigar Co.'s Plant—We have been informed by Clark, MacMullen & Riley, 101 Park Ave., New York City, that the plant of the American Cigar Co., Garfield, N. J., described by W. L. Durand in Apr. 6 issue was designed and installed by them. This building is the first in the country used exclusively for cigar manufacturing to put in an air-washing system.

Vacuum Fluid Cooler

This device has been designed for the purpose of reducing the temperature of water below that of the surrounding atmosphere. Referring to Fig. 1, where the

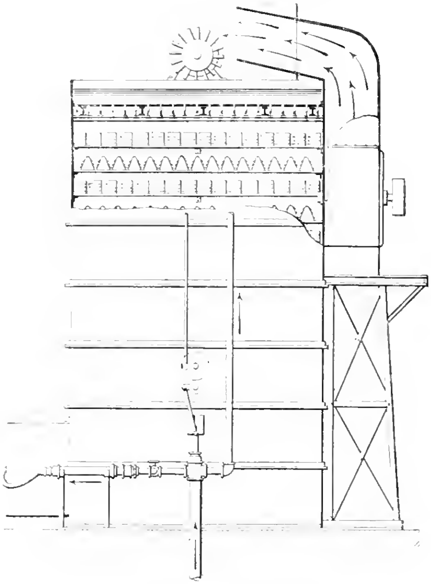


Fig. 1. Cooling Tower

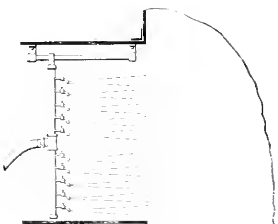


FIG.2

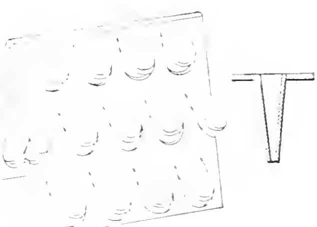


FIG 4

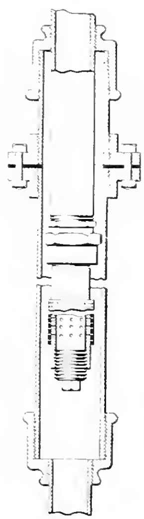


FIG 3

Fig. 2. Air-Cooling Chamber. Fig. 3. Strainer. Fig. 4. Tongued Baffle Plates

cooler is shown in the form of a rectangular tower, the air is taken through the air-cooling chamber, details of which are shown in Fig. 2, at a velocity of about 2000 ft. per min. In this chamber is a manifold sprayer which subdivides the water after it has passed through a strainer, Fig. 3. As the air enters through the cooling chamber it is compressed by passing through a smaller orifice at a high velocity, and is thereby reduced to about 65 deg., at which temperature it is drawn through the cooler and comes in direct contact with the falling water. The method of baffling the water and the air by means of tongued baffle plates, Fig. 4, causes the drops of water to

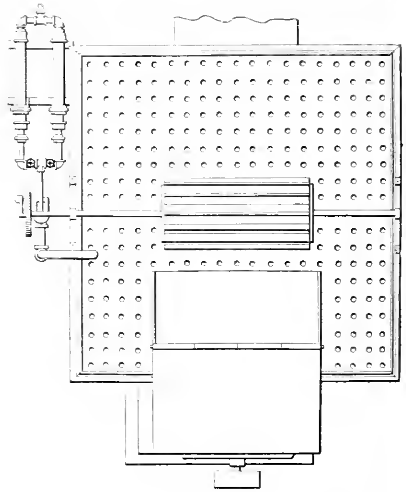


Fig. 5. Perforated Steel Pan

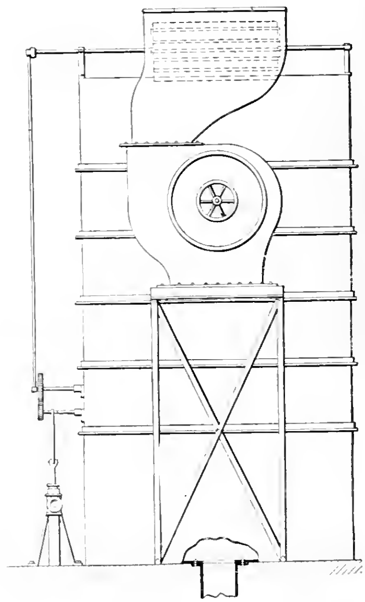


Fig. 6. End View of Cooling Tower

come in contact with the cooler air twelve or fourteen times during their fall from the inlet to the outlet.

At the top of the cooler is a steel pan about twenty inches deep (Fig. 5), into which the hot water from the condenser is pumped and the bottom of which is perforated at regular intervals with 1-in. holes. Each hole is connected to a funnel-shaped tube, Fig. 4, which tapers to 1/4 in. diameter at the base, thus forming sprayers. These tubes are so designed that with the weight of water which passes through it is impossible for them to become clogged or to retain any foreign matter that may be in the water.

The water is distributed to the tubes in the form of a spray, and when sufficient is in the pan to cover the holes, the exhaust fan, Fig. 6, placed under the tube, forms a partial vacuum into which is precipitated the falling hot water and vapor.

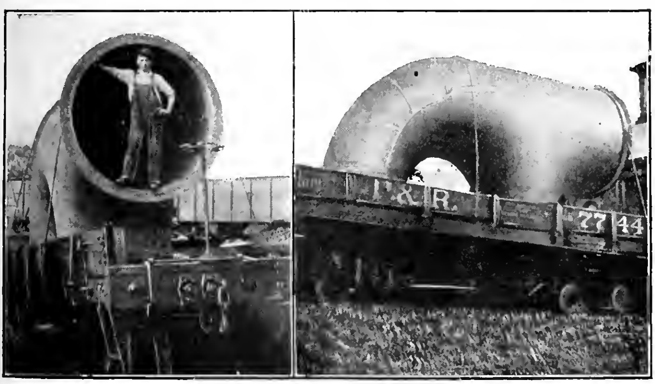
The exhaust is under the top pan. By circulating the water through the cooler after it has been heated from 90 to 160 deg. F. in passing through a condenser, it is brought back to be used again at a temperature of 70 to 75 deg. F. after passing through the cooler.

This cooling tower is manufactured by the Vacuum Flue & Cooler Co., 205 Highland Bldg., South Highland Ave., Pittsburgh, Penn.

Large Double Exhaust Fitting

The accompanying illustration shows a 72-in., cast-iron, double exhaust fitting which was recently made in the shops of the Hunsicker Engineering Co., Lebanon, Penn. So far as known this is the largest fitting of its kind ever made in the East.

It is used in connection with a 5000-kv.-a. turbine, 1500 r.p.m., at 80 lb. boiler pressure. The condenser used in the equipment is a No. 23 barometric type. The double outlets connect with the expansion joints of the turbine and the large end connects with a 72-in. exhaust line. It weighs 14 tons and is 18 ft. in length over all.



Two Views of 72-In. Double Exhaust Fitting

The Efficiency of Compressed Air can be greatly increased by reheating. The gains are both direct and indirect, the chief direct gain being in the greatly increased efficiency of fuel used in the heating stoves as compared with the effect when coal is burned under boilers. It is commonly stated, and the statement is fairly correct, that when 1 lb. of coal is burned in a reheater stove the commercial effect is as great as when 3 lb. are burned under a boiler. The increase in commercial efficiency when reheating air from 60 deg. F. to 400 deg. F. may be put at 35 per cent. The indirect gains are better lubrication of the compressed-air engine, less investment required, as a smaller plant will be needed, reduction of compressor-engine friction as compared with the useful work done.—Exchange.

Belting Calculations

By E. O. Waters

The theory of belting, as presented in standard handbooks, does not seem to harmonize with examples taken from everyday practice. There appears to be conflict between textbook theory and machine-shop practice, but this conflict is more apparent than real.

Primarily, a belt is made in such a length that it will be stretched enough to give it an initial tension. When the driving pulley starts it will cause one-half of the belt to tighten and the other half to become more or less slack. When the difference in tensions becomes slightly greater than the resistance of the driven pulley, it, in turn, will start up, provided the resistance does not exceed the maximum value determined by the coefficient of friction between the belt and pulley surface and the arc of contact made by the belt. This maximum ratio is that number whose common logarithm is $0.00758\mu\theta$, where μ is the coefficient of friction and θ is the arc of contact measured in degrees. For any proposed installation of belting θ is known (it is usually about 180°); and μ was determined many years ago by hanging pieces of belting with weights attached to the ends, over fixed sheaves, and finding out what excess weight hanging from one end was required to produce slipping. Accordingly, our maximum limit for $\frac{T_t}{T_s}$ is fixed, and since $T_t - T_s$ is determined by the power to be transmitted and the belt speed, we have only to make T_t and T_s large enough so that their ratio will be within the required limit, and to choose a belt sufficiently wide and thick to stand this maximum pull.

Suppose, for example, that it is desired to transmit 100 hp. between two 30-in. cast-iron pulleys, 30 ft. apart and on the same level, at a belt speed of 2500 ft. per minute. The resistance of the driven pulley will be 1320 lb. at the rim, and this same figure will represent the excess of T_t over T_s. Since the arc of contact is 180 deg., and μ, according to the experiments referred to above, is about 0.3, $\frac{T_t}{T_s}$ must be greater than 2161 lb. and T_s greater than 841 lb. Of course, the excess will be made as small as possible in order to avoid undue pressure on the shaft bearings and an unnecessarily large belt; but there must be an actual excess, or the belt will soon stretch permanently—so much so that it will be necessary to shorten it by cutting out a piece, so as to keep it from slipping. As for the size of belt to be used, the standard rule of 111 lb. maximum tension per inch width of double belt, corresponding to a maximum tension of about 375 lb. per sq.in., gives us a belt having 5.75 sq.in. sectional area, which would probably mean a double belt 20 in. wide. According to F. W. Taylor's recommendations, the maximum tension should be only 54 lb. per inch width of double belt, if it is desired to have belts which will give the least expense for repairs and lost time on machinery. In that case, our calculations show that a 30-in. double belt or, preferably, a 20-in. quadruple belt must be used.

So much for the design of belting transmissions by theoretical formulas. On the other side of the question, our own observation tells us, first, that for transmitting 100 hp. at 2500 ft. per min., very few factories use belts much over 20 in. wide and 3/8 in. thick, and second, that such belts, when running between pulleys a considerable distance apart, will often sag on the loose side anywhere from one-third to three-quarters of the mean diameter of the pulleys. Now we can very easily find the tension at the two ends of the loose portion of the belt by means of a little mechanics and the use of the well-known fact that a belt or rope, when suspended between two points, hangs approximately in a parabolic curve whose equation is

$$y = \frac{wx^2}{2H}$$

in which

y = Vertical distance of any part of the belt from the lowest point;

x = Horizontal distance of the same point from the lowest point;

w = Weight per unit length, and

H = Tension at the lowest point.

Taking $y = 2$ ft. and $x = 15$ ft., corresponding to a point on the loose side of the belt just as it is leaving one of the pulleys, and assuming the weight of leather as 0.036 lb. per cu.in., we have, for the 20-in. double belt, $w = 2.47$ lb. per ft. and $H = 139$ lb. At one end of the span the tension T_s will consist of a horizontal component equal to 139 lb. and a vertical component equal to the weight of half the span, or approximately 37 lb. This gives us $T_s = 143.8$ lb., which, to say the least, does not check very well with the minimum value of 841 lb. obtained by theoretical deductions. Even if the heavier belt were used, according to Taylor's recommendations, w and H would merely be doubled, and T_s would then be 288 lb.

In the opinion of the writer this discrepancy is due to two things—the arc of contact and the coefficient of friction assumed in the theoretical formula $\log \frac{T_t}{T_s} = 0.00758\mu\theta$. The arc is increased very materially by a slight sag in the loose side of the belt, if that side is the upper one. In our problem a sag of 2 ft. at the middle of the span means an increase of about 15 deg. in the arc of contact, and this difference alone is enough to increase the allowable ratio of $\frac{T_t}{T_s}$ from 2.57 to 2.78. However, a much greater change is caused by the second factor. It is not generally known that the coefficient of friction is very decidedly increased by slippage between the belt and pulley surfaces, although this fact seems to have been recognized many years ago by several investigators of the practical mechanics of belting. Unwin gives the equation $\mu = 0.2 + 0.001\sqrt{V}$, where V is the belt velocity in feet per minute, on the assumption that the amount of slip will increase as the speed of a belt becomes greater. Barth, after making a very careful analysis of some tests carried out by Wilfred Lewis for Wm. Sellers & Co., deduced the two following equations: $\mu = 0.6 - \frac{2}{4 + v}$ where v is the velocity of slippage of the belt relative to one of the pulleys, in feet per minute, and in the other $\mu = 0.54 - \frac{140}{500 + V}$.

The last of these, like Unwin's equation, depends only on the velocity of the belt, and is supposed to be used for ordinary belt transmissions where the total slip between the driving and driven pulleys is about 1½ per cent. Now a slip of 3 per cent. is very common in belting practice, and for belts that are running at all loose it may easily reach 6 per cent. In such a case, a belt running at 2500 ft. per min. will slip over each pulley with a velocity of 75 ft. per min., and μ, according to Barth's first formula, = 0.575. At that rate, the ratio $\frac{T_t}{T_s}$, as figured by the same equation that gave us $\frac{T_t}{T_s} = 2.57$, may be increased to 7.1, and T_t and T_s, instead of being, respectively, 2161 lb. and 841 lb., are reduced to 1536 lb. and 216 lb. This value of the tension in the loose side of the belt lies about half way between the tension which it was figured would be required to support a 20-in. double belt with a 2-ft. sag between the pulleys, and that required for a 20-in. quadruple or 40-in. double belt with the same sag. In other words, a 20-in. triple belt can be used in the transmission which we have been figuring, and allowed to sag 2 ft. on the loose side, in spite of the preliminary calculations which showed that such a heavy initial tension would be needed that the belt would pass from pulley to pulley in practically straight lines.

The upshot of the whole matter seems to be this: Almost any value within reason for the ratio $\frac{T_t}{T_s}$ may be obtained by calculation, simply by juggling with the coefficient of friction; it is therefore worse than useless to use the standard formulas for the design of belt transmissions, unless we take into account such factors as the belt's speed and slip, which are usually neglected. If, however, we can get a pretty accurate value for the coefficient of friction, we can figure belt tensions which will agree quite satisfactorily with those which we observe in practice. It should be noted that this can be done without in any way taking into account the effects of centrifugal force, which, in the opinion of some, should be given the entire credit for making it possible to run slack belts.

Economy of Heating Feed Water

By C. E. Anderson

Notwithstanding the economy of using exhaust steam for heating water for boiler feed and other purposes and the widespread information on the subject, the writer is constantly coming in contact with cases where live steam is used for heating water and for other purposes where exhaust steam might readily be employed.

Theory and practice prove beyond a doubt that a saving of 10 to 20 per cent. in coal consumption may be effected by heating feed water, the amount varying according to conditions. Where large quantities of hot water are used for other purposes a much greater saving may be made by using exhaust instead of live steam to heat it. In some cases it is more economical to run noncondensing, but if the exhaust furnished by the pumps and other auxiliary machinery is nearly enough, it is good practice to make up the deficiency by bleeding the intermediate receiver.

The following calculations may be of interest, showing the value of the feed-water heater. For convenience, assume a heater working continuously at its full capacity for ten hours a day and supplied with exhaust steam from the average noncondensing engine developing about 75 hp. Taking water at 60 deg. F., the heater will deliver about 1200 gal. per hour, or 12,000 gal. per day at about 210 deg. F. One gallon of water weighs about $8\frac{1}{3}$ lb., and 12,000 gal. will weigh 100,000 lb. Since it requires 150 heat units (B.t.u.) to heat one pound of water from 60 deg. F. to 210 deg. F., 100,000 lb. requires 15,000,000 heat units.

Roughly speaking, one pound (weight) of live steam will furnish 1000 heat units, therefore, 15,000 lb. of live steam would be required to do the work. Under good conditions one pound of coal will evaporate 10 lb. of water. This figure may be exceeded in some instances, but probably the majority of cases fall below it. On this basis no less than 1500 lb. of coal per day will be required. Assuming a working year of 300 days, this gives a total of 450,000 lb., or 225 tons, of coal burned, which at $4 per ton would cost $900.

This sum represents the saving by the use of a heater with exhaust steam. Of course, these figures are arbitrary and the result will be more or less fully realized in practice, according to circumstances.

Curnon Steam Meter

The Curnon Steam Meter is nothing more than the familiar low-pressure recording gage of the diaphragm type, and its pressure regulator which utilizes the Bourdon tube. The meter is sensitive and fairly accurate. The charts used with the instrument are directly calibrated in pounds of steam per hour, so that no calculations are necessary to secure the desired data. The installation is simplified by the use of double cocks both on the test plug and on the meter.

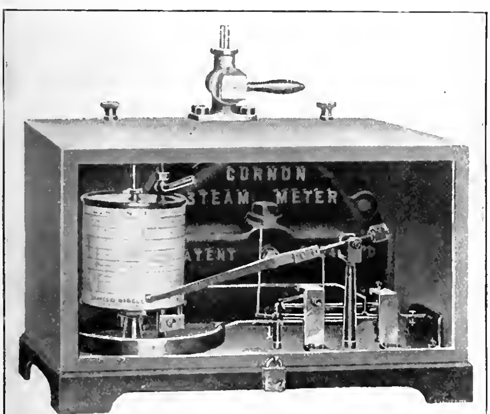


Fig. 1. Curnon Steam Meter

The principle employed in this meter, Fig. 1, is that of the Pitot tube, consisting of two small tubes with their ends bent at right angles and inserted in the pipe in which the steam is flowing in such manner that the end of one faces against, and that of the other with, the direction of flow. The rush of steam past the tubes causes in one a slight increase, and in the other a corresponding decrease, in the static pressure in the pipe. The difference in pressure is a measure of the velocity of the steam, and by connecting the two tubes to a sensitive differential pressure recorder a record is obtained of the quantity of steam passing through the pipe to which it is attached. Fig. 2 shows the Pitot tube mounted in the Curnon plug. The special feature is that the tubes are of such length

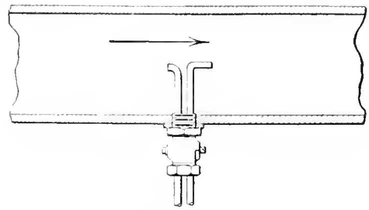


Fig. 2. Arrangement of the Pitot Tube

as to reach exactly to the center of the pipe, where the speed of the flow is highest and where eddy currents are least likely to interfere with the accuracy of the measurements. The low-pressure tube has a long elbow, which further increases the pressure difference and the motive power available to secure clear records of small variation in load. A single three-way cross controls both tubes and enables steam to be blown through them for cleaning purposes.

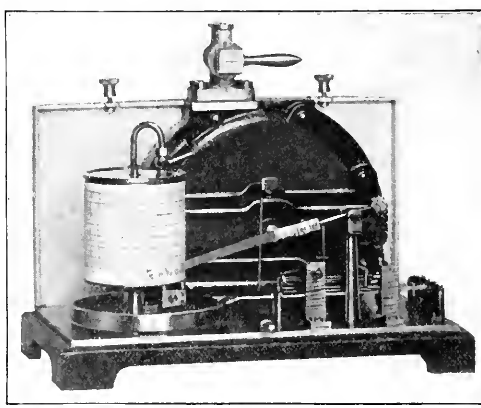


Fig. 3. Meter without Casing

All of the moving parts are mounted on a cast-iron base, as shown in Fig. 1. The outside dimensions when mounted in a box are 15x9x9 in. and the weight is about fifty pounds. Fig. 4 is a view of the diaphragm box, which is arranged in the back plate of the meter case. The two pressures in the test plug act upon the sides of a sensitive diaphragm, which is stiffened by two plates and controlled by a strong flat spring. The movements of the diaphragm are conveyed to the pen through a system of levers which multiply and rectify the movement in such a way that the curves traced upon the paper chart directly represent the weight of steam passing through the pipes.

As the accuracy of the instrument would be affected by any variation in boiler pressure, each is fitted with an automatic pressure regulator consisting mainly of a hollow spring of the Bourdon type, arranged centrally below the recording drum and linked at its free end to the multiplying gear. This is shown in Figs. 1 and 3. The interior of the Bourdon tube is in communication with the steam pressure in the pipe, and the movement of the free end so acts upon the pin gear as to automatically correct the reading for any fluctuation in pressure.

The connection between the meter and the 3/8-in. copper test tube may be any reasonable distance away, either above or below the pipe.

The double cock, shown in Figs. 1 and 3, at the top, is constructed so that both ports are opened and closed simultaneously. In the closed position the meter is connected to the atmosphere and the pen must always stand at zero on the chart. This enables the operator to check the adjustments at any time. Between the plug and the meter are the condenser coils, which consist of 3/8-in. copper tubing fitted to the plug horizontally and on an exact level with the Pitot tube in the steam space. The

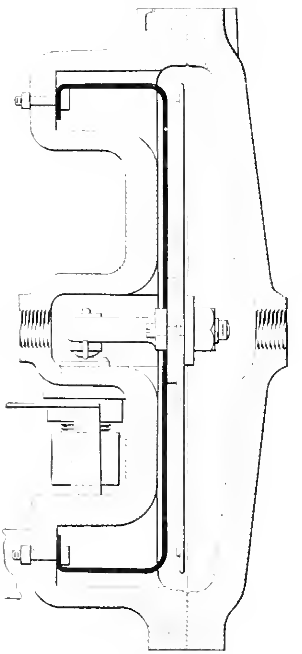


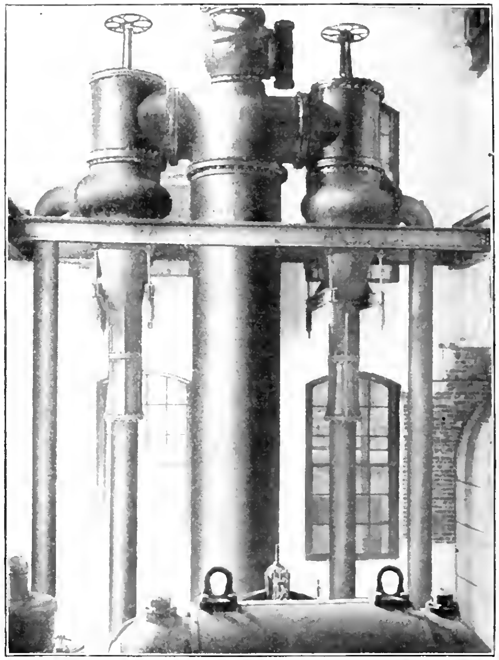
Fig. 1. Diaphragm Box in Section

condensing coils insure that the meter, as well as the connecting pipe, is always filled with comparatively cold water, regardless of the displacement due to the movement of the diaphragm.

The meter is manufactured by the James Biddle Co., 1211 Arch St., Philadelphia, Penn. Each one is supplied with a test book, condenser coil, two 10-ft. copper connecting tubes and 100 charts and ink. The standard charts are calibrated in pounds of steam power and are available in various ranges for each size of pipe. The instrument is fitted with a 24-hr. chart and an 8-day clock.

Deane Ejector Condenser

The illustration shows a pair of 34-in. ejector condensers recently installed by the Deane Steam Pump Co. in the city electric generating plant of Holyoke, Mass. The apparatus serves a 3500-kw. horizontal double-flow turbine and maintains 28 to 28½ in. of vacuum in the turbine exhaust chamber.



A Pair of 34-In. Ejector Condensers

In the construction a lifting device has been provided to permit the cone to be raised to discharge any trash which may stop the annular opening in the condenser after passing through the strainer. The tees shown at the top of the condenser are so designed that the cone can be lifted through the tee in case of desired changes, repairs or alterations. A pointer on the cone-raising spindle indicates the amount of opening around the cone. A device has also been incorporated to center the cone and prevent vibration of the lower edge when it is in its working position. The long run of 50-in. exhaust-steam riser and the 16-in. injection pipes are noticeable. These are both made of lap-welded steel tubing. The exhaust-steam riser is in one piece 25 ft. 8¾ in. long and the injection risers and the drop pipes are also each in one piece. Expansion and contraction of the piping under varying temperatures are taken care of by spring suspensions.

Formidable Looking Formulas—Many engineers will go down without a struggle before a formula which has a logarithm, entropy or a sine, cosine or tangent in it. It is just as simple to look up one of these quantities and to substitute the value given in the table for the letters of the formula as it is to hunt up the steam temperature corresponding to a given pressure, or the area corresponding to a given diameter, and the same book which contains the tables of the properties of steam and of circumferences and areas will usually have the other things, too.

Editorials

Changes at Seventy-Fourth Street

There are few more forceful examples of what the economy of the large steam turbine means in the generation of power than the recent changes in the Seventy-Fourth Street station of the Interborough Rapid Transit Company, New York City, which are described in this issue. When it pays to discard to the junk pile engines of large power, nearly as good as new, to make room for turbo-generator units, it shows that designers have been accomplishing things. And yet, in doing so they undo their admirable work of but a short time ago.

These great engines should not go into oblivion without a word being recorded of their life's history, too much of which has perhaps already been forgotten. The installation in the Seventy-Fourth Street station in 1901, beside being one of the most notable, was virtually the last stand of the large reciprocating engine for electric generating units.

They were designed by that Connecticut farmer boy, Edwin Reynolds, who became one of the eminent figures in the steam-engineering history of the country. It is told that Mr. Reynolds was invited to New York to discuss with the Manhattan Railway Company's engineers the subject of selecting the type of engine for the Seventy-Fourth Street station. When he left the E. P. Allis works in Milwaukee, the question was unsettled. At Albany a telegram informed him that a committee representing the railway company would meet him at the Grand Central station. When he reached Harlem, the story goes, he had sketched on the back of a letter the design ultimately adopted, the sizes of cylinders and principal parts being indicated. And the problem was to crowd 12,000 horsepower in each engine, which had to go in a limited space.

It seems that Fate had decided that this daring stroke should be about the last, for the turbine was beginning to demonstrate its possibilities. The first important installation was in 1899, when some 400-kilowatt machines were put in the plant of the Westinghouse Air Brake Company. About a year later attention here and abroad was centered in the two 2000-kilowatt units of the Electric Light & Power Company, Hartford, Conn. This was the most notable installation in point of capacity and because the expansion was completed in one cylinder. Then came the announcement that several 5000-kilowatt units were being built for the combined station of the Metropolitan and District roads, London.

The fact was being established that the larger the capacity of the turbine the more favorable was its performance, and 1905 saw contracts closed for a 10,000-kilowatt Brown-Boveri-Parsons machine for the Westphalian Electricity Works, Essen, Germany. At this time the Brooklyn Heights Railroad Company got two 7500-kilowatt units, which were then the largest turbines in this country.

There next followed the first real tryout of the turbine on a large scale, when in 1905 about 10,000 kilowatts in turbines were run in competition with a nearly equal capacity of reciprocating engines in the L-Street station of the Boston Edison Company. The results of these competitive trials do not need to be told.

And all this truly remarkable advance had been made almost simultaneously with the installation of large reciprocating engines in such stations as the Seventy-Fourth Street of the Interborough Rapid Transit Company; Waterside, No. 2, of the New York Edison Company, new in 1902; and the Fifty-Ninth Street station of the Interborough Rapid Transit Company, new in 1904. This is the most conclusive evidence that the early development of the turbine was rapid beyond the expectations of the best engineering talent of the time.

"Elbow Room" in Power-Station Design

If power-plant designers generally were experienced in station operation, more consideration would be given to adequate space for equipment and attendance. The temptation to cut down on space is great, to save in the amount of material required to inclose the plant and in the fixed charges per horsepower of capacity. This consideration limits stations built in country districts as well as those on valuable city land, and the operating staff frequently finds itself lacking in room.

Some of the difficulties of attempting to operate in a cramped location may well be considered as an offset to the demands of an initial layout extremely economical in structural material. The importance of adequate clearance will be conceded by any student of "safety first." Where bare conductors are to carry high voltage, the designer generally appreciates the element of clearance. It is fully as important in many low-voltage plants to provide adequate spacing between conductors and metal work and between lines and horizontal or vertical passages. The commercial value of the loads carried, even if there were no personal hazard in the crowding of live conductors into restricted spaces, often makes it inadvisable to take chances of interruptions. It should never be possible for an engineer, climbing an iron ladder and momentarily losing his grip, to swing outward so far as to touch the exposed contacts of an instrument transformer. Designers who will properly separate circuits carrying high voltages sometimes neglect to spend enough money on low-tension bus structures and switch cells to protect the service and the operator from mischances.

A thorough investigation of the relation between the labor cost of station service and the space requirements of the plants covered would be of much interest. Equipment arrangement is important, but accessibility and freedom to reach apparatus without traversing circuitous paths are also. Main units are rarely so crowded today in new stations as to hamper removing sections of machinery, but in the placing of auxiliaries and in the arrangement of piping, valves and platforms, much is often to be desired. A construction engineer who rose to a high place in a consulting organization recently remarked that few things in his early experience had proved of greater value than several months of service as a substation operator after the close of each day's work in the drafting department. The actual handling of the equipment gave him a knowledge of space requirements that was reflected in his later work. He knew what room the switchboard operator needed to manipulate manually connected switch levers in critical moments; he appreciated the desirability of being able to read instruments easily from all apparatus-controlling points; and he realized the handicap of crowded motor-generator sets and transformers closely adjacent to railings or too near aisles for rapid movement.

In order to get the benefit of the reduced labor cost per kilowatt of capacity of modern generating units, it is worth while to make sure that subordinate equipment is sufficiently separated to enable it to be operated and maintained without adding needlessly to the station payroll through the comparative inaccessibility or obstructive features of the apparatus and its arrangement. Ample space in which to use tools specially adapted to the adjustment of complex machinery and fittings is of enough value to justify, usually, at least a moderate increase in building cost. In other words, flexibility and compactness are not always synonymous in first-class designing.

Unreasonable License Laws

Nobody would deny that it is the duty of the state to see that boilers are safe and that they are safely operated.

If a factory inspector makes you provide fire escapes and put guards around gears and belts, if a plumbing inspector insists that the plumbing, even of your dwelling, shall be sanitarily installed, if the fire and insurance authorities can dictate how much combustible or explosive material you can have around and how you must keep it, surely somebody should pass upon the adequacy of steam boilers, to the consequences of the failure of which not only industrial workers, but occupants of office buildings, customers of department stores, guests of hotels, and even the pedestrian upon the street, are subjected.

Nobody would deny that the state—which is the people—should provide for the safety of the people by the inspection of these boilers and of the man who runs them—if that were all that there is of it.

The man who owns boilers and hires men to run them is afraid that this will not be all.

When he sees laws passed, denying to a man the privilege of working at his vocation because he was not born and brought up in the town where the job is—

When he sees rules adopted, denying to an engineer coming into a community, be he the best engineer in the world, anything except a chance to work in a subordinate capacity, with the lowest grade of license—

When he sees examiners acting in collusion with organized labor, to keep down the supply of engineers by refusing men licenses to run steam plants because they cannot design triple-expansion engines—

When he sees engineers' organizations straining the interpretation of existing laws so as to require every laborer about a steam plant to be a licensed man—

He is afraid that the legislation, however beneficent in its declared purpose, however innocent in its seeming intent, is of sinister design and hostile to his interests.

Most of the opposition to the passage of engineers' license laws is inspired by this fear. Most of the difficulties experienced by the A. S. M. E. committee appointed to formulate standard specifications for the construction of steam boilers and other pressure vessels and for the care of the same in service came because it included in its report a recommended form of license law. As one member put it, "this committee, appointed to get up a blueprint of a horizontal return-tubular boiler, tried to involve the society in objectionable legislation." The only way that the report could be gotten through at all was by leaving out all reference to legislation and all suggestions for laws which would bring about the adoption of the Code by the various states.

As we started in by saying, nobody has any tenable objection to the adoption of boiler inspection and engineers' examination laws, when he is satisfied that they are not excuses to add to the difficulties of the employer and subterfuges to obtain unnatural and unfair advantages for the present holders of jobs in power plants under a specious anxiety for the public safety.

The real effort for such laws is sincere and honest, and those who are making it should most forcibly disavow any ulterior purpose in their agitation and frame their proposed legislation so that it cannot be abused.

It is hoped that the American Society of Mechanical Engineers' Code, above referred to, will come into universal use in this country. Its adoption by the various states, for which powerful interests are striving, opens the way to, if it does not go hand in hand with, the examination and licensing of engineers. Those who are seeking legislation to bring this about should unite their efforts with those who are striving for the boiler-inspection laws and make their demand so reasonable and so sensible that they cannot reasonably be denied.

Effect of High Steam Pressure on Flywheel Risks

In the days when seventy pounds was so usual a steam pressure that it was taken by the committee on boiler trials of the Centennial Exposition as representing average practice, such an occurrence as a flywheel explosion was almost unheard of. The maximum mean effective pressure which could possibly be gotten was that which would result from carrying seventy pounds full stroke. With an initial pressure of one hundred and fifty pounds, the attainable mean effective pressure in case something goes wrong with the governor is more than twice as great. This means that the velocity generated in a given time would be more than twice as great; but since the centrifugal force increases as the square of the velocity, the stress generated in the flywheel in a given time would be over four times as great. An accident which prompt action, under the less strenuous conditions of twoscore years ago, would have headed off, would be likely to be all over now before the attendant could gather his wits, get into motion, and close the throttle.

Correspondence

Rate Discrimination in Massachusetts

In the Feb. 23 issue there appeared an item dealing with the attempt of the New England Power League to get a bill through the Massachusetts Legislature tending to make more equitable the rates for electricity. Perhaps it would be interesting to your readers to learn more as to why the League takes this attitude.

The schedule of the Boston Edison Co. appears to be the only one which is susceptible of having curves plotted which mean anything; but the conditions existing in most of the other electric companies in the state are the same as shown by the curves of the Edison company. There is no difference, so far as results are concerned, between a charge for the privilege of being connected to the lines plus a charge for the power delivered, and charging a high price to the small consumer and a low price to the large consumer. Twelve cents a kilowatt-hour to a small consumer and one cent to the large one represent the range in power costs in Massachusetts. This applies to both demand plus a current charge and a straight charge.

To illustrate the Boston Edison schedule, Fig. 1 has been drawn, which shows that from 0 to 15 kw. there is a demand charge of $60 per kilowatt per year. From 15 kw. upward, this demand charge decreases, and at 10,000

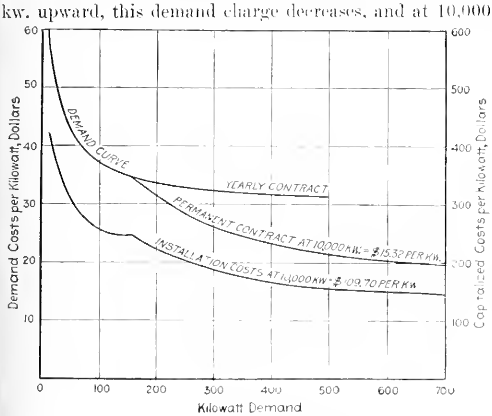


Fig. 1. Demand Charges

kw. demand is $15.32 per year. This applies to permanent rates, that is, to those who make a permanent contract for more than one year. If the contract is only for a year, the reduction is not so great; but even under these conditions, at 500 kw. the demand charge is only $31.20.

Capitalizing these charges, the lower curve is obtained, which would indicate that from 0 to 15 kw., the cost per kilowatt of demand is $128; whereas at 10,000 kw. it is only $109.70. This in itself is rank discrimination, because it is impossible that a city plant could be built with the necessary distributing lines at $109.70 per kilowatt. It is even worse than it appears on the surface, because of the diversity factor.

It has been proved by one of the largest companies that the diversity factor of the large load is practically unity, whereas that of the small load ranges between 3 and 4; that is, a large consumer will usually require in the power

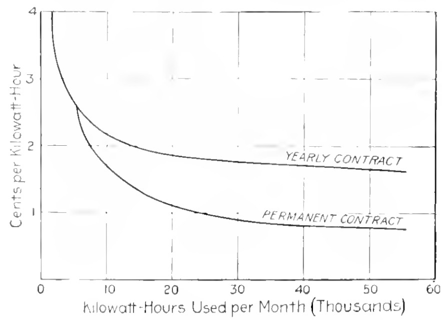


Fig. 2. Prices for Energy Used

plant a capacity equal to his maximum demand, whereas the small consumer will require an installation in the power plant equivalent to only one-third or one-quarter of his maximum demand. As the large consumer is charged for a value less than one-third of the actual cost of the apparatus, the small one on the other hand is charged at a value of three to four times those shown on the capitalized demand costs, or from $1282 to $1712 per kilowatt of actual station capacity.

These figures alone are sufficient to make the New England Power League and others feel that it is time some laws were passed which would make an equitable division of the power costs.

Another item of discrimination is the division between yearly and permanent contracts. It will be noted from Fig. 1 that from 15 to 155 kw., yearly and permanent contracts are the same, but that above 155 kw. there is a decided difference. To my mind this is discrimination, because there should be no point at which these two contracts should be the same if there is any reason for a division between the two characters of contract. If it costs more to handle yearly customers than it does permanent ones, it will cost more for any character of load.

So far attention has been called only to the demand, and it will be noted that there is a wide variation in demand charges. Let us look now at the energy used. Fig. 2 shows the variation in these charges for various consumptions in kilowatt-hours per month. It will be noted that here again there is a marked decrease in cost solely for an increase in the amount of current used. It would seem that if there were a large difference in the cost for the demand, there should be a uniform price for the current, for certainly the demand charges as laid out cover much more than the fixed charges on the small load, and do not cover nearly as much as the fixed charges on the large load. Therefore, in order to even matters up, it would seem as though the power charges for current delivered should be uniform. They are not, and again the small consumer gets the worst of it. Up to 1500 kw.-hr., he has to pay 5c. per kw.-hr. From this point on, the rate decreases to a marked extent, until at 55,500 kw.-hr. the price is under 2c. for permanent rates. For yearly rates, however, the price is approximately 2.6c. Here again there is a division between the yearly and the permanent rates. As has been stated before, if there is any reason for a division, it should apply to all characters of load; but it does not. The division takes place at 5500 kw.-hr. per month.

In my opinion there is no question as to the injustice and discriminatory feature of the demand charge as outlined, as well as the current charge; and I am heartily in favor of any attempt which may be made to bring about a more uniform and just arrangement of charges for electric light and power.

HENRY D. JACKSON.

Boston, Mass.

Priming a Centrifugal Pump

This is a problem which confronts many operators of centrifugal pumps. In the Mar. 2 issue there is an article on this subject by J. F. Jones, in which he describes the trouble he had in priming a 30-in. pump. While his method is all right, it does not exhaust all of the air from inside the casing, and no doubt there is considerable "rumbling" in the pump while it is in operation, with a possible chance of injuring the impeller. By referring to Fig. 2 of Mr. Jones' article, it will be seen that it is impossible to remove all the air from inside of that part of the casing which is above the point where the ejector suction enters the suction elbow on the pump. By running with air entrapped inside the casing, the delivery is no doubt reduced.

When a pump such as that shown by Mr. Jones is started with air inside the casing, it is difficult to get rid of all of it through the discharge pipe. What might be a more satisfactory way to prime this pump would be to connect the ejector as shown in Fig. 2 of Mr. Jones' arti-

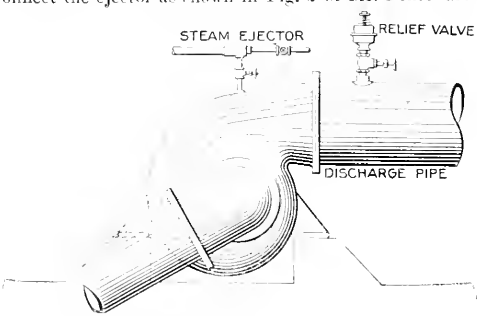


FIG. 1. POSITIONS OF EJECTOR AND RELIEF VALVE

cle, except that the suction should be cross-connected to the top of the casing. The method of starting would be the same as that adopted by Mr. Jones, except that after the pump is running and before stopping the ejector, the latter's suction to the top of the pump should be opened and that to the elbow closed. This will exhaust the air from the top of the casing. In this way the delivery should be better than if there were some air in the casing.

It is not always best to leave off the flap valve, and it is often necessary to have one on the end of the discharge pipe. When a flap valve is used it is necessary when shutting down, to have some way of breaking the vacuum in the discharge pipe which is due to the water running back down the pipe and through the pump.

The possibility of collapsing the discharge pipe on a pump such as that described by Mr. Jones, can be avoided by placing a relief valve near the flap valve on the discharge pipe. The position of this relief valve is shown in Fig. 1. It should be placed on the highest point of the discharge pipe.

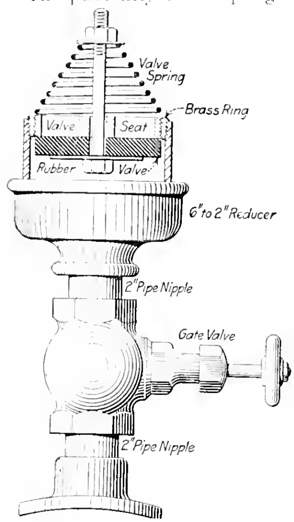


FIG. 2. RELIEF VALVE

A suitable relief valve can be made as shown in Fig. 2. The spring for holding the valve on its seat should be of such strength as to allow the valve to open when a vacuum of about 20 in. of mercury is produced inside the discharge pipe. The opening will permit air to enter, thus breaking the vacuum and preventing the possibility of collapsing the discharge pipe. An ordinary rubber pump valve and seat are shown as making up this relief valve. A gate valve should be placed as shown. This is left open while the pump is running, and if for any reason the pump should stop and the flap valve close, the relief valve would open automatically when the vacuum inside the discharge pipe became great enough to overcome the pressure of the spring.

J. E. POCHE.

New Orleans, La.

Some Reasons for Different Rates

In the issue of Mar. 16, Mr. Seed has an interesting article showing the reasons for different rates and using the cutting and delivery of ice as an illustration.

In his figures it appears that the cost of labor decreases much too rapidly in the handling of the various quantities of ice; also the investment cost. It is hard to conceive that the investment will decrease from $1.50 a ton to 45c. with an increase of four times the amount handled. It costs more to add a story to an icehouse than just the labor and material. Furthermore, the reduction in prices to the various large consumers is not as great as will probably take place in actual conditions, and nothing like as great as in electric sales, where the ratio of the small to the very large consumers' rate is often 10 to 1, and the small consumers' rate to the average, about 6 to 1. Mr. Seed's greatest variation is 4 to 1, when the largest consumer has no delivery cost at all.

In answering his question, "If Jones found it necessary to give up a part of his business and had his choice, which part would he drop?" it all depends on the figures. If he sold two tons at $8 per ton, and they cost delivered $12.30, there would be a gross profit of $3.70. If he sold the next three tons at $4 a ton and they cost him $13.45, he would have a loss of $1.45. If he sold five tons at $2.50 a ton and they cost him $15.75, he would have a loss of $3.25. If he sold ten tons at $1 and they cost him $11.50, he would have a loss of $1.50. Under these conditions which would he choose? These figures correspond more closely with actual electric prices, as is shown by the following table. One of the large companies sold power as follows:

	Kilowatt-Hours	Receipts	Cost
Motor service	25,471,000	$1,114,624	$743,000
Street railway	8,319,000	142,987	242,200
Street lights	17,739,000	781,792	516,500
Commercial lighting, small	24,568,000	2,457,000	715,000
Commercial lighting, large	42,495,000	1,792,000	1,249,000
Other companies	4,248,000	121,530	123,700

These costs, like those shown in Mr. Seed's illustration, are the average operating costs of the plant and do not take into account interest or depreciation. If the company had to choose which class of customer it would drop, which would seem the more probable—the small one, paying 10c., or the large one, paying considerably less?

I realize that the figures given here do not recognize many differences in expense to the various characters of load, the cost being the average as shown by the Public Service Commission's report. At the same time, I believe that this illustration shows the absolute futility of trying to compare the manufacture and sale of electricity with ice.

Electricity must be sold as it is manufactured, because it is not possible to store it commercially. This being the case, if we have a customer or group of customers who will demand a certain definite load all day, giving unity power factor, the investment is used to its maximum and therefore the price of the power should be low. If, however, another customer comes along who requires power for only a short period, an additional investment is compelled; and as the power is used but a short time, the investment is used but a short time and the fixed charges are high; and also, as the machinery is used but a short time, the labor charges are large, which means increased cost. This latter is to all intents and purposes the condition which exists with the large power users. During the summer they can be run very largely from the plant which is installed to handle the lighting load; but during the winter they cannot, and apparatus which is idle during the rest of the year has to be put into the plant to meet the power load. This being the case, the investment charges against these power users are very large. This will counterbalance any inaccuracy of the figures given above when taken in the sense of neglecting the interest and depreciation charges; they are comparable and accurate if these charges are taken into account.

HENRY D. JACKSON.

Boston, Mass.

That all do not reach the same conclusion from the same starting point is well illustrated in the letter of Mr. Seed on page 383. Using the same figures given, if Jones supplied only one of the classes of customers and could take his pick it would be as follows:

To consumers taking 50 to 100 lb.:

Two tons at $8 per ton		$16.00
Cost of two tons at $2.50	$5.00	
Cost of team	5.00	
Cost of two men	5.00	
		15.00
Gross profit		$1.00
Profit per ton, $0.50.		

To markets, etc., 200 to 500 lb. per delivery:

Three tons at $6 per ton		$18.00
Cost of three tons at $2.50	$7.50	
Cost of team	5.00	
Cost of men	5.00	
		17.50
Gross profit		$0.50
Profit per ton, $0.16⅔.		

For ice-cream factories, etc., 1000 to 2000 lb.:

Five tons at $4 per ton		$20.00
Cost of five tons at $2.50	$12.50	
Cost of team	5.00	
Cost of two men	5.00	
		22.50
Gross loss		$2.50
Loss per ton, $0.50.		

To Smith & Brown, 10 tons at icehouse:

Ten tons at $2 per ton	$20.00
Cost of ten tons at $2.50	25.00
Gross loss	$5.00
Loss per ton, $0.50.	

It is seen that the small consumer is the only one who pays much profit alone. Whom woeld Jones serve if he could get only one class?

Using the figures exactly as Mr. Seed gives them and supplying all classes, the profit per ton is

Small consumer	2 tons, proﬁt $3.70,	per ton	$1.85
Markets, etc.	3 tons, profit 4.55,	per ton	1.51⅔
Ice-cream factories	5 tons, profit 4.25,	per ton	0.85
Smith & Brown	10 tons, profit 8.50,	per ton	0.85

Jones will sell more ice to small consumers than to the other classes, and if he could only sell 1000 tons it is easily seen to which class he would prefer to sell.

I still fail to see why the large consumer should get all the benefit of cheaper production or pay so much less profit per unit.

HARRY D. EVERETT.

Washington, D. C.

Testing Small Centrifugal Pumps

In the Mar. 16 issue M. R. Blish makes two mistakes in defining the method of computing the head on a centrifugal pump. On page 372 he states that the total head is the sum of "the suction head, pressure head, and the vertical distance between the center of the pressure gage and the point of attachment of the mercury gage." The first error is the omission of a velocity-head correction. It is quite common for the suction pipe on a centrifugal pump to be a size larger than the discharge pipe, in which event we should have to include the difference between the velocity heads in the suction and discharge piping at the points where the gages are attached. This may be proved in various ways, but may readily be seen if we but realize that it requires power to increase the kinetic energy of the water as well as to increase its pressure. Only where the two pipes are of the same diameter, so that the velocity-head correction is zero, would Mr. Blish's definition apply.

The second error is that here, as well as on page 371, he implies that the indication of the mercury manometer is the value of the pressure at the point of its attachment to the suction gage. It is well known that a pressure gage reads the pressure found within itself and that its height must be considered in finding the value of the pressure at the point of attachment. The same is true of a suction gage. If the suction head is read by means of a vacuum gage, the definition of total head should be corrected to read, *and the vertical distance between the centers of the pressure and vacuum gages.* If the suction head is read by a mercury manometer, the point corresponding to the center of the vacuum gage will be the top of the mercury column on the side of the U-tube that is connected to the pump.

The words in italics are based upon the assumption that there is a continuous column of water between the vacuum gage or the mercury manometer and the point of attachment to the suction pipe. Such a condition may be realized if the connecting tubing be filled with water before the pump is started and if the point of attachment is not at a place where a pocket of air may accumulate. If the connecting tubing contains air only, then Mr. Blish's method of computation would be correct. This is because the weight of the column of air between the mercury manometer and the suction pipe is negligible and hence the manometer reading would be the value of the pressure at the point of attachment. In order to maintain this condition, however, it is necessary to have some means of permitting air to be drawn into the connecting tubing during a test, allowing water that has accumulated to be drawn back into the suction pipe. The figure shown in the article does not indicate any such provision. Unless one does have some means of admitting a small quantity of air during the test, it is better to fill the connecting tubing with water. Otherwise, if the tubing contains water and air both, it will be difficult to properly compute the true suction pressure. In the case of a pump delivering water under a high head and where the vertical distance from the suction gage to the suction pipe is small, the error introduced may be negligible, but under other circumstances it might be appreciable.

Objection must also be raised to the arrangement of suction piping shown in Fig. 3, on page 371. It is a fundamental principle that a suction pipe must contain no summits, otherwise air will accumulate and finally interfere with the flow of water or cause it to cease.

Mr. Blish seems to have the impression that the insertion of bafflles in a weir box is to "prevent a serious velocity of approach." Baffles are used to quiet the water and cause it to flow uniformly, but have no effect upon the velocity of approach. The latter is determined solely by the dimensions of the cross-section of the box.

In connection with measuring the rate of discharge of the pump, the author might have mentioned the most common method used in testing, which is by means of a calibrated nozzle on the end of the pipe. Also the venturi meter is a valuable device for such purposes.

In starting a centrifugal pump, the author states that after priming, "open the throttle valve in the delivery pipe and start the motor." While this may be permissible with proper starting devices at the motor, a better procedure would be to bring the pump up to speed before opening the discharge valve. In that way a smaller load would be thrown on the motor at starting, since the horsepower with the valve closed is about one-third that required with the valve wide open.

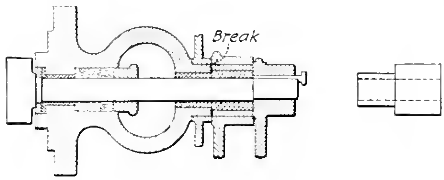
The efficiency curves shown in Fig. 7 for speeds of 1200, 1400 and 1650 r.p.m. are consistent with one another, but the curve for a speed of 1700 r.p.m. is somewhat doubtful. When there is an increase in the maximum efficiency of only about 3 per cent. for a range of speed from 1200 to 1650, it is hardly likely that there will be a drop of about 8 per cent. in passing from 1650 to 1700 r.p.m. Further, it will be noted that the maximum efficiency at each speed is attained at greater values of the rate of discharge as the speed increases for the first three speeds, but for 1700 r.p.m. the maximum efficiency is shown as occurring at a smaller rate of discharge than at 1650 r.p.m. This is hardly reasonable and makes one suspicious of the accuracy of the test data used.

R. L. DAUGHERTY.

Ithaca, N. Y.

Repairing Corliss Valve Bonnet

One of the admission-valve stems and bonnet bearings on a Corliss engine got overheated from running dry, until it gripped and broke the bonnet, as shown. A good repair job was done by boring out the bonnet and making a



VALVE BONNET WITH BUSHING

sleeve, or bushing, a driving fit. After forcing it into the bonnet it was turned down and bored out to fit the valve stem.

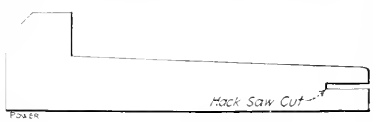
When the parts were reassembled very little adjustment was needed to set the valve to the builder's marks. The job was done in four hours by two men.

JOHN POWERS.

New Bedford, Mass.

Putting Liners in with Keys

When a key is too loose and it is necessary to put a liner in with it, there is sometimes difficulty in getting the liner to go in with the key, or if the liner is put in first, to get it to stay in place while the key is being driven. To overcome the foregoing, I saw the end of the key, as shown, and insert the end of the liner, doubled



SLOT IN KEY FOR LINER

if necessary, and bend it back along one face of the key. Whether the liner should be placed on the one face or the other depends on the depth and relative smoothness of the keyways.

CHARLES HERMAN.

New York City.

Replacing Broken Capscrews

Referring to the subject of the letter by A. G. Solomon, page 414, Mar. 23, this difficulty seems to be quite common. Three years ago I had some trouble with a small ammonia-compressor cylinder held in place by eight ⅞-in. capscrews. The screws would become loose and the cylinder would slip on the bedplate at each stroke.

I overcame the trouble in a way similar to that described by Mr. Solomon, but more simple. I drilled a ¾-in. hole 2 in. deep at the joint of the cylinder flange and the frame, then fitted a dowel pin and drove it in tight. Since then there has been no difficulty in keeping the cylinder rigid.

L. M. Johnson.

Emsworth, Penn.

In the issue of Mar. 23, page 414, I notice an account of a method used to prevent the breaking of the capscrews used to secure the cylinder of an ammonia compressor to the base.

No doubt, putting in tight-fitting keys would prevent breaking more bolts, but if this means were used on a steam cylinder, I am afraid that before a great while the base would be broken, unless some provision were made for the expansion and contraction of the cylinder, which apparently was not done in the case of the ammonia cylinder.

To fit bolts snugly into the holes is wrong, in my opinion, for the cylinder is heated and expands, while the base remains practically cool and expands very little, thereby putting a shearing stress on the bolts. If the bolt holes had been elongated about ⅛ in., I believe the trouble would have been overcome without the expense of putting in the keys. I would advise using only one key in any case, and enlarging the holes in the other end to allow for expansion, as stated.

H. S. Mellen.

Philadelphia, Penn.

Gas Explosions in Boiler Furnaces

I would like to bring to your attention a recent accident in one of our boiler rooms, with the suggestion that it be published, and commented on by readers.

The boilers were of the vertical water-tube type, provided with two sets of fire-doors with automatic stokers (underfeed) between them. Forced draft for all the boilers was furnished by an automatically regulated engine-driven blower, supplemented by natural draft from the stack.

Owing to some minor troubles it had been necessary to cut out one of the two boilers in operation the night before the accident and it, together with the third boiler, had both the natural and the forced draft cut off by the dampers, leaving only one boiler in service to carry the load. This was being forced, with the stack damper wide open, the blower running at full capacity and the stoker rapidly feeding coal. The fireman in cleaning the fire (with only one fire-door open) found a clinker had formed over the tuyeres. As he loosened this an explosion occurred in the firebox, precipitating him backward against the coal bunker and burning him severely. The engineer, who was standing directly in front of the other fire-door of the same boiler, was not injured, as the safety latches on the latter (which had been installed after two similar occurrences of a minor nature) prevented its opening, thus justifying their adoption. But the cleaning-out door at the base of the stack was blown open by the force of the explosion, which appears to have been considerable.

Presumably, this was a carbon-monoxide explosion facilitated by the sudden inflow of air through the tuyeres when the latter were cleared. The lower limit of the explosive range of carbon monoxide in air is in the neighborhood of 15 per cent., and it is difficult to understand how such a rich mixture as this could have remained in the firebox with one fire-door open and the stack draft in operation. We might add that all ashpit doors were sealed and that it is the practice at this works to keep all stack dampers wide open on boilers which have fires under them. When it is necessary to cut out a boiler the forced draft is shut off, and as soon as the fire is dead the damper is closed.

We referred a description of this accident to three prominent companies, one of them supplying forced-draft equipment with turbine blowers, one supplying forced-draft equipment with steam blowers, and the third a well-known boiler insurance company; also calling their attention to a letter in Power of Mar. 18, 1913, on a carbon-monoxide explosion. Their comments are in part as follows:

First Letter—

We never had any experience of this sort, nor have we ever heard of any with the exception of one case in the writer's early experience with forced draft.

The power plant consisted of six water-tube boilers with which, on account of poor draft, it was difficult at times to keep up steam pressure. The ashpit doors had been removed. The writer recommended forced draft and made a test on one boiler with a turbine blower which was very noisy. To reduce the noise we decided to build a duct around the blower and run it up to within 10 ft. of the boiler-house roof, but as we were not sure that this would give the desired results, we built it of wood and had it lined with shoddy and used cardboard to keep it in place.

During the night the fireman was not able to keep down the steam pressure even with all dampers closed, something which had never happened before, and he closed the ashpit doors of the one boiler which was equipped with the blower, and no doubt also opened the fire-doors of all the boilers. After a while there was an explosion, and the duct caught fire and also set fire to the roof of the boiler room. The writer's explanation of this explosion was as follows: The ashpit doors were closed and the fire-doors open. The damper of the boiler was closed. The duct acted as a chimney and the air went through the fuel bed, caused the formation of carbon monoxide, which went into the ashpit through the blower and up the duct. This heated up the duct, and through leaks around the blower enough air got into the duct to mix with the carbon monoxide and cause the explosion. This experience and other trouble with this particular blower were among the causes that led to the inception of our present type of blower.

We have in the neighborhood of a thousand installations and, as stated before, we have never had trouble on account of carbon monoxide, though many of our installations are operated automatically, so that when the steam pressure goes up both the blower and the damper close and finally shut down completely. Many other forced-draft systems are operated in the same manner.

The letter to "Power" to which you refer is quite interesting, and the only explanation that the writer can give for such an occurrence is that a steam-jet blower was used. This type of blower is small in diameter and the air goes through at a high velocity, and consequently, when shut down little air goes through it by the draft of the chimney. No doubt the damper was also closed, and perhaps just prior to the blower being shut down there was a high rate of combustion and a high temperature of the fuel bed. On account of all this the combustion continued, but not enough air being present, it was incomplete, and carbon monoxide was produced.

With a turbine blower conditions are different. When it is shut down there is enough air going through the fan casing through natural draft to cause complete combustion provided the damper is not entirely closed. We do not recommend stopping the blower, but we have never thought of the carbon-monoxide danger, but simply do not recommend it on account of believing it desirable to change as little as possible the temperature of the fuel bed. In other words, we recommend that the blowers be run at the slowest rate for the lightest load and be speeded up when the load increases.

We do not think it possible that a high percentage of carbon monoxide can be reached with the dampers open and the fire-doors and ashpit doors closed, and we do not think it possible even with the damper closed provided the blower is not being run at full speed at one time and shut down completely afterward. It should be run at as near as possible the same speed all the time, this speed of course depending upon the variation in demand for steam. We have never considered it unsafe to automatically close off the blower when the boiler pressure reaches a certain point, though, as stated before, we do not recommend it. But in view of the two experiences mentioned in your letter we would not now consider it safe to shut the blower completely and the damper at the same time when the temperature of the fire is high. If the damper is open there will be no danger when the blower is stopped provided the blower is large enough so that the air can pass through it by natural draft.

Second Letter—

We have your favor referring to the explosion in a boiler at one of your works. We have heard of this occurring. The case we have in mind was one in which the damper in the stack or main breeching was closed at the time the explosion took place. We can readily conceive of such a condition, that is, damper closed and gases being given off by the coal with insufficient air supply, with the result that a large volume of CO forms. Then when more air is admitted, although the blower is started, it may be possible for an explosion to occur from the higher temperature resulting with a renewal of combustion, particularly if the stack damper is closed and the gases confined.

Apparently, in your case the damper was open, since you point out that the clean-out door in the base of the stack was forced open by the explosion. This would appear to indicate that your stack was small and that the suction was insufficient.

Such explosions are much more likely to occur in the combustion of soft than of hard coal, on account of the presence of the hydrocarbon gases, which are so much more volatile. We are not inclined to believe that so high a percentage of CO can be formed with the damper open, even though both the ash- and fire-doors be closed.

With regard to operation, the method we recommend is the automatic action of the main blower line by means of a balanced valve and automatic regulator, with a bypass around the former so as to keep the blowers going continuously, the regulator taking care of the slight fluctuations in the load. If the load is extremely variable, then it may be possible to install a balanced valve in the bypass where the throttle valve is, this balanced valve being controlled by another regulator to shut off at a point, say 5 lb. higher than the first regulator. If, on the other hand, the periods of high and of low loads are known and are not too frequent, then this condition can be best corrected by opening, more or less, the throttle valve in the bypass to the balanced valve in the blower line.

Third Letter—

We have had considerable experience on gas explosions, due to carbon monoxide from soft coal, from natural gas, etc., but are unable to advise you definitely as to the lowest range or percentage of carbon monoxide and air that would result in an explosion. While this particular feature is worth investigation as of scientific interest, yet the percentage of such air and gas mixtures in a furnace will, of course, vary widely.

Assuming conditions as described in your letter, we presume the fire-doors, etc., were so arranged that no air was permitted to enter above the fire, the supply being from the blower system. Therefore, with the tuyere openings blocked with clinkers and no air admitted above the fire, carbon monoxide would be generated faster than it could escape, and the furnace, and even the chimney (with one boiler chimney), would be filled with carbon monoxide, which would rapidly be built up to a point where it would be explosive.

It seems if the damper had been open, say 50 per cent., when the fireman opened the fire-door the draft would have quickly carried away the carbon monoxide and thus averted the accident. The matter of closing dampers from 75 to 95 per cent. while the furnace is loaded with coal which is setting free its volatile constituents strikes us as wrong. In our opinion the damper should have a limit closure when a boiler is in service.

In the last comment it is evident that the writer overlooked the points that the opening of the fire-door supplied air above the fire and that if the clean-out door in the base of the stack was blown open, the damper must necessarily have been open—as was actually the case. As for the amount of CO necessary for explosion, Von Schwartz, in "Fire and Explosion Risks," cites Professor Bunte, of Carlsruhe, as authority for 16.6 per cent. and 74.8 per cent. as the lower and upper limits of the amount of CO in admixture with air which will permit explosion when ignited by an electric spark, at the same time stating that the explosion of such can be prevented by the addition of 7½ to 10 per cent. CO_2. Von Schwartz also gives the approximate figures of 13 to 75 per cent. for ignition by flame and 636 to 814 deg. C. as the temperature at which pure CO will explode without air.

From a preventive standpoint the comments quoted do not give much information, and we are at a loss to know how to guard against explosions of this character with this particular installation. We have experienced dust explosions from the loosening of deposits of soot in the flues, oil-gas explosions with oil-fired systems, carbon-monoxide explosions from negligence in completely closing stack dampers and also severe accidents from flarebacks from boilers equipped with steam-blower systems—the latter caused by too high steam pressure or by firing the coal too far back in the furnace, where it obstructed the draft. For all these there seem to have been reasonable remedies, but for a case such as that mentioned we see no cure other than instructions to keep the tuyere openings clear of clinkers, which was, after all, what the fireman was trying to do.

A general discussion by qualified persons would be appreciated.

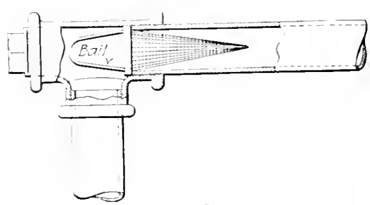
L. A. De Blois,
E. I. du Pont de Nemours Powder Co.

Wilmington, Del.

Strainer in Pump Suction

I have found that a strainer, made as shown in the illustration saves a lot of trouble by preventing small sticks and stones entering the pump and lodging under the valves.

The strainer is made fast to a brass ring, which will hold against the end of the pipe and keep the screen from



Removable Strainer

being drawn into the pump. A handle, or bail, is convenient to pull the strainer out for cleaning. A tee is used in the suction pipe instead of an elbow, and the strainer put in as shown, and a plug is used to close the end of the tee and to make the appliance easily accessible. The mesh of the screen should be suitable to the size of the pump and the kind of service. Brass or copper wire is preferable, but galvanized wire will answer in some cases.

Ithaca, N. Y. John P. Kolar.

Inquiries of General Interest

Side for Connecting Equalizing Switch—On which side of an electric generator should the equalizing switch be connected?

W. H. M.

An equalizing switch is to be connected on whichever side of the generator the series field winding is placed.

Vacuum Not Ascertainable from Temperature—Would determination of temperature of the condensate discharged from a condenser be an accurate method of measuring condenser pressure by ascertaining pressures corresponding to temperatures given in the steam tables?

A. J. F.

The temperature of the condensate would not be a true indication of the pressure, on account of the presence of air in the condenser.

Backfiring Trouble—Would placing a wire screen in the intake pipe of a gasoline engine between the carburetor and cylinder prevent backfiring?

C. E. S.

A screen would undoubtedly prevent backfiring through the intake pipe, but would not remove the cause of imperfect operation of the engine. The backfiring may be due to wrong timing of the ignition, improper seating of the inlet valve, thus allowing the exploding mixture to get by it into the intake pipe, or a combination of a lean mixture and too early ignition.

Measure of Ductility—What is the measure of the ductility of a metal?

E. H.

The percentage elongation and the percentage reduction of area are usually considered together as the measure of the ductility of a metal. After a bar of the material under tensile stress has passed its elastic limit it begins to be permanently elongated in the direction of the pull. The increase in length multiplied by 100 and divided by the original length is the "percentage elongation." When a bar is elongated it shrinks in cross-section, and just before it breaks it usually "necks down" at the point of fracture. The original cross-sectional area minus the area of smallest cross-section after fracture is called the "reduction area," and this difference multiplied by 100 and divided by the original area is the "percentage reduction of area."

Increase of Bolt Tension after Cooling—If a 1½-in. diameter steel bolt is drawn up tight when at the temperature of 160 deg. F., how much will its tension be increased after it has cooled to 70 deg. F.?

R. B. N.

If there is no yielding of the head, nut or screw from compressive stresses, the additional tensile stress in the bolt due to cooling will be the same as that required for elongating the bolt as much as it would elongate or contract for the same change of temperature. The coefficient of lineal expansion or contraction of steel is 0.0000065 of its length per degree change of temperature, and therefore the elongation or contraction per inch of length for a change of 160 — 70 = 90 deg. F. would be

$$0.0000065 \times 90 = 0.000585 \text{ in.}$$

As for steel, the modulus of elasticity, or load per square inch of cross-sectional area divided by the extension per inch of length, is 30,000,000, then for an extension of 0.000585 in. the stress would be

$$0.000585 \times 30{,}000{,}000 = 17{,}550 \text{ lb.}$$

per square inch of cross-sectional area, and for 1½-in. bolt, or a cross-sectional area of

$$1\tfrac{1}{2} \times 1\tfrac{1}{2} \times 0.7854 = 1.767 \text{ sq.in.,}$$

the stress would be

$$17{,}550 \times 1.767 = 31{,}010.85 \text{ lb.}$$

Size of Feed Pump—What size of single feed pump should be employed for a boiler which requires 3850 lb. of feed water per hour?

W. H. M.

A uniform feed-water supply would be equivalent to

$$3850 \div 8\tfrac{1}{3} = 462 \text{ gal.}$$

per hour, requiring a pump displacement of

$$(462 \times 231) \div 60 = 1778.7 \text{ cu.in. per min.}$$

But to meet emergencies the rated capacity should be about double the delivery required for uniform rate of feeding, i.e., neglecting slippage and reduction of piston area due to the piston rod, the displacement capacity should be about 3558 cu.in. per min. Allowing a maximum speed of 60 strokes per minute the piston displacement should be $\frac{3558}{60}$, or about 60 cu.in. per stroke.

To determine the size of water cylinder, either the area of the piston or the length of the stroke must be selected. Neglecting slippage and reduction of the area of piston due to the piston rod and assuming the diameter of water cylinder as 3¼ in., the area of the piston would be

$$3\tfrac{1}{4} \times 3\tfrac{1}{4} \times 0.7854 = 8.2958 \text{ sq.in.}$$

requiring a stroke of

$$\frac{60}{8.2958} = 7.23 \text{ in.}$$

and for most practical purposes the commercial size, 5½x3¼x7 in. (5½-in. diameter of steam cylinder, 3¼-in. diameter of water cylinder, 7-in. stroke) would answer.

Pressure Required for Running Noncondensing—If an engine, operated with steam at an initial pressure of 120 lb. absolute, ¼ cutoff and 26 in. vacuum, loses its vacuum, what initial pressure would be required to operate the engine noncondensing with the same length of cutoff, the valve setting and load remaining unchanged?

S. S.

The mean forward pressure per pound of initial is given approximately by the formula

$$P_m = (1 + \log_e R)\ (f + c) - c$$

in which

P_m = Mean forward pressure per pound of initial (absolute);

$\log_e R$ = Hyperbolic logarithm of the ratio of expansion;

R = Ratio of expansion $= \frac{1+c}{f+c}$

f = Fraction of stroke completed at cutoff;

c = Clearance per cent. of piston displacement.

Assuming 5 per cent. clearance, the ratio of expansion would be

$$\frac{1+c}{f+c} = \frac{1+0.05}{0.25+0.05} = 3.5$$

and as the hyperbolic logarithm of 3.5 is 1.2528, the mean forward pressure per pound of initial would be

$$(1 + 1.2528)\ (0.25 + 0.05) - 0.05 = 0.6258 \text{ lb.}$$

and for 120 lb. initial absolute the mean forward pressure would be

$$120 \times 0.6258 = 75.1 \text{ lb.}$$

When running condensing with 26-in. vacuum the back pressure would be

$$30 - 26 = 4 \text{ in. mercury,}$$

or

$$4 \times 0.491 = 1.964 \text{ lb. absolute,}$$

and the m.e.p. of an ideal diagram would be

$$75.1 - 1.964 = 73.136 \text{ lb. m.e.p.}$$

but when running noncondensing the back pressure would be about 1.5 lb. gage, or about

$$15 + 1.5 = 16.5 \text{ lb. absolute}$$

and to obtain the same m.e.p. (73.136 lb.) for the ideal diagram the mean forward pressure would need to be

$$73.136 + 16.5 = 89.636 \text{ lb.}$$

If in each instance the actual is the same per cent. of the ideal diagram, and as the mean forward pressure when cutting off at ¼ stroke is 0.6258 lb. per pound initial absolute, then to realize a mean forward pressure of 89.636 lb. absolute would require

$$89.636 \div 0.6258 = 143.2 \text{ lb. absolute,}$$

or about

$$143.2 - 15 = 128.2 \text{ gage pressure.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Convertible Combustion Engines*

By Alan E. L. Chorlton

One might at first sight say that the combustion engine most ready to work on different fuels would be of the self-ignition type, in which the heat of compression is sufficient to ignite the incoming fuel, and the only change necessary in going from liquid to solid fuel would be in the fuel-injection device. In practice, however, owing to the difficulty with solid-fuel injection, such a type would not prove workable, and even when the fuel is first gasified the results do not justify the complication. The problem of designing an engine is better met by trying to combine known types for gas and oil, in which good results are obtained at present and which in general principles show the same characteristics.

In the normal engines for both gas and oil the chief difference lies in the degree of compression. Thus, the compression of a modern gas engine may vary from 90 lb. when using coke-oven gas, to 150 lb. for producer gas; while for the liquid-fuel engine using crude or residual oils the compression pressure may exceed 500 lb., but may be considerably less if the temperature of ignition is obtained by uncooled surfaces or auxiliary or pocket firing is used.

As there is no fundamental difference in engines for gaseous or liquid fuels except in their conventional cycles, it follows that any schemes of convertibility must provide means whereby the requisite compressions can be readily obtained, but as there is a great gap between 500 and 150 lb., the tendency is to combine the lower-compression oil engine and the higher-compression gas engine and thus deal with a smaller compression-pressure range. The desirable characteristics of the convertible engine are: Simplicity and reliability, high economy for each fuel, first cost (little above that of the standard engine), easy convertibility, and as nearly as possible the same power developed for each fuel.

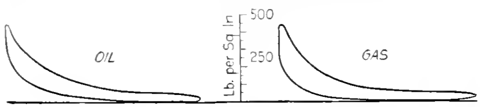


Fig. 2. Indicator Diagrams with Oil and with Gas

Consideration of the subject may be more clearly undertaken by dividing the types of engines in use into three groups, with further subdivisions, due to peculiarities of design: (1) Engines of low compression and low power; (2) engines of high compression and higher power; (3) engines of medium compression and higher power.

GROUP 1—As an example of the first group, take the ordinary motor-car engine having a compression up to 90 lb., and which, with slight modifications, will run on gasoline, good kerosene with an exhaust-heated carburetor, town gas and producer gas. It is designed for and works best on gasoline; fairly well, however, but not so economically, on town gas; requires very good kerosene and is not efficient at the low-compression with producer gas.

To extend the range to use a poorer grade of kerosene or a good grade of crude oil, means must be provided whereby more heat is available for the ignition. This can be conveniently done by the addition of an unjacketed portion to the cylinder head; then the engine becomes of the hot-bulb type. A change of parts for such an engine does not present any difficulties. The gas fittings are provided with electric ignition, which is also suitable when gasoline is used, while the kerosene and good crude oil would be self-ignited by the hot bulb. Fig. 1 illustrates the practical application of these modifications. The results obtained with this engine, are:

	Compression, Lb. per Sq.In.	Maximum Pressure, Lb.	M.E.P. Lb.	B.t.u. per B.hp.-hr.
Kerosene	55	210	58	14,500
Producer gas	90	230	65	12,000

This type of engine is suitable only for comparatively low powers, and the range of fuels does not include any heavier than good crude oil. Furthermore, its economy on oil is not high. It is described here because it contains the basic principles of a more suitable engine for large powers.

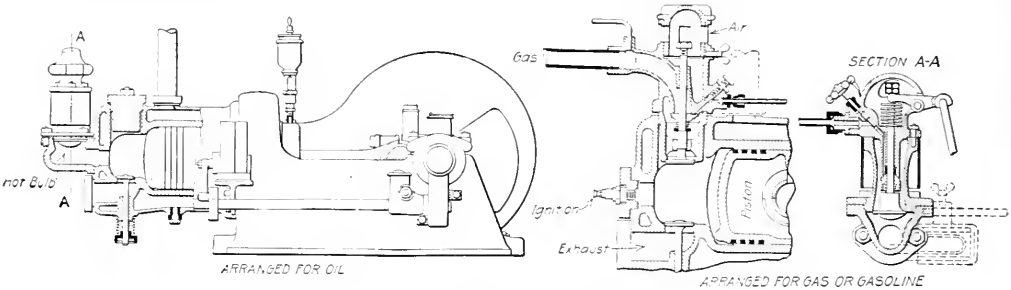


Fig. 1. Convertible Engine for Small Powers Using Gas and Liquid Fuel

GROUP 2—This group is represented by the Diesel engine, with a compression of over 500 lb. when using tar oils (unless an ignition oil is used). As the maximum compression for gas normally does not exceed 150 lb., there are mechanical difficulties in building an engine in which both of these compressions can be obtained with reasonable modification. Furthermore, the Diesel has an expensive high-pressure compressor which is unnecessary for the ordinary type of gas engine. Apart from mechanical difficulties, we may compare the commercial possibilities of this type, the oil and gas sides being as follows for engines of the same cylinder dimensions:

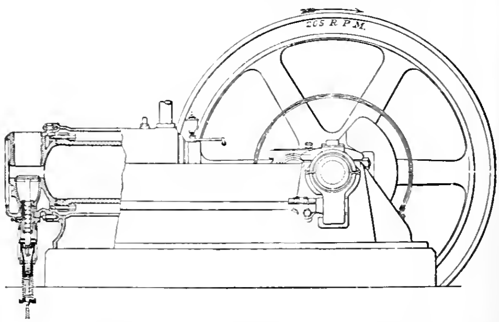


Fig. 3. Convertible Engine with Exhaust Valve Attached but without Head

	Compression, Lb. per Sq.In.	Abnormal Maximum Pressure, Lb.	M.E.P. Lb.	Approx. B.t.u. per B.hp.-hr.
Oil engine....	500	Over 1000	100-110	8000
Gas engine...	150	600	80	8500

These figures show how incompatible the two designs are, for they illustrate that the Diesel structure must be built twice as strong for the very high maximum possible pressure, owing to the fuel valve sticking, etc. The higher

*Read before the Institution of Mechanical Engineers, London, on Feb. 19, 1915.

mean effective pressure used is some compensation for this extra cost and weight. The mean cylinder pressures reveal a still further disadvantage when the gas conversion is considered; for besides this high first cost, there is a reduced power, owing to working at a lower mean effective pressure—80 as against 100-110 lb. A convertible engine on these lines does not seem a commercial possibility.

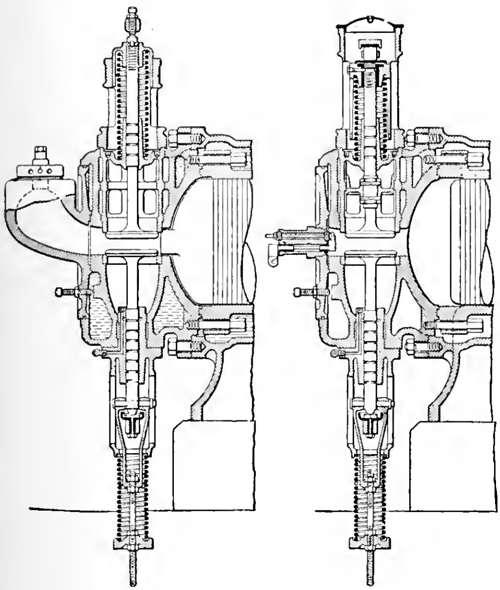


FIG. 4. SAME ENGINE AS IN FIG. 3 ARRANGED FOR OIL AND FOR GAS

GROUP 3—The range of the compression of these engines lies between that of Groups 1 and 2, and usually is from 150 to 300 lb. A compression of 150 lb. is suitable for most forms of producer gas, but because of preignition it is not usually exceeded. On the other hand, it is necessary for all compressions below self-ignition pressure to employ some auxiliary means to obtain the necessary temperature for the proper combustion of the residue oil. Normally, the additional heat is obtained by an unjacketed surface or ignition bulb at the cylinder end.

The various devices concerning temperatures, compression and convertibility of this group may be considered by subdividing it under the following heads:

a. Engines working with a compression not exceeding 150 lb. both for oil and gas, and which may employ pocket-firing with or without air injection for one and electrical ignition for the other, or some combination, the smaller compression not involving material mechanical changes of the parts.

b. Engines working with a higher compression for oil than gas, involving some modification of the combustion chamber by substitution of a part for oil as against a part for gas; otherwise maintaining the simplicity of both types.

c. Engines obtaining the necessary change from gas to oil by temperature control of the air charge, together with alteration of the valve settings.

d. Engines employing the super-compression of Dr. Dugald Clerk, to control effectively the compression required for either fuel. (Final ignition temperature by other means.)

Under subdivision a there are a large number of engines used only for oil, but which might, without much alteration, become effective in the use of gas, although the whole combination is not as efficient as the highest individual member.

In considering division b, a useful comparison of its possibilities is given in tabular form, for engines of the same cylinder dimensions:

	Compression, Lb. per Sq.In.	Abnormal Maximum Pressure, Lb.	M.E.P. Lb.	B.t.u. per B.hp.-hr.
Oil engine.........	250-280	600	80	8100
Gas engine.........	150	600	80	8500

It will be seen from this that the outputs and general figures relative to the engine bear a great similarity. Moreover, the diagrams of Fig. 2, taken when running on oil and on gas, are similar. Therefore, the possibilities of this type of convertible engine appear great, and an engine which has been made in considerable numbers to fulfill these conditions is shown in Figs. 3 and 4. (Built by Messrs. Ruston, Proctor & Co., Ltd.) These views show clearly that in both cases the engine presents the ordinary features of the four-stroke-cycle type, and the only change involved in converting from oil to gas lies around the combustion bulb of the oil engine, and in the change from an oil-type to a gas-type piston.

The arrangements in division c may be justified for mechanical and constructional convenience, but they can hardly be defended on the score of efficiency. In one method the jacket of the cylinder cover is formed to withstand a pressure, and is worked in the manner of a boiler. The increased heat is impressed in the charge of air during the compression stroke to raise the temperature sufficiently for ignition. This arrangement thus replaces the hot-bulb or unjacketed end of the cylinder. It has some advantages, in that it is perhaps more controllable and the steam generated may be used for some useful purpose, perhaps in conjunction with an exhaust-heated boiler for an auxiliary steam cylinder on the main engine. The water injection of some hot-bulb engines is also done away with. This type of engine is unusual in practice.

When in use as a gas engine, such a convertible machine would have to dispense with the pressure-jacket temperature when using the lower compression and temperature needed for such an engine. Actual heating of the inlet air may be a practical convenience for dealing with a particularly refractory oil not amenable to the available compression of the engine. The valve setting may be modified to give suitable compressions for oil and gas; this can be worked in conjunction with the temperature arrangement just described. The gas engine, however, suffers in loss of output.

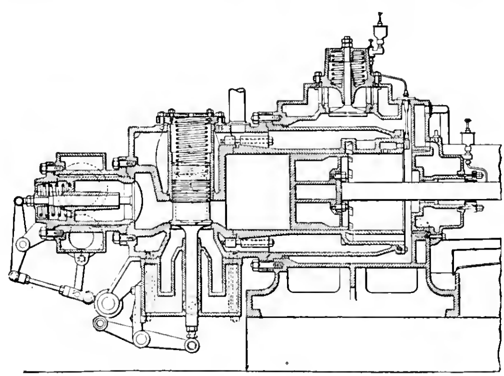


FIG. 5. SECTION THROUGH CLERK SUPER-COMPRESSION ENGINE

The Clerk super-compression engine (Fig. 5) is a much more suitable and promising type for dealing with the variable compression problem of the convertible engine. In this, an extra charge of air or inert gas is added to the working mixture at the end of the suction stroke, by which means much lower maximum flame temperatures are obtained and a higher mean cylinder pressure is rendered possible. As a convertible engine, it is particularly suitable, for by varying this amount of added air the compression can be adjusted between wide limits, the final temperature being controlled by any of the previously indicated means. For instance, with a compression of 300 lb. maximum, the full displacement of the air pump may be used; for the lower compression of the gas engine one can, by any suitable valvular means such as an ordinary bypass, reduce the amount of discharge as required.

CONCLUSION—The conclusions of the author are that, for powers up to say 1000 b.hp., a type such as the Ruston is the most suitable as a convertible engine, while for still larger powers, when tandem engines and size and weight of removable parts become a problem, the Clerk super-compression type offers very interesting and hopeful possibilities in this field.

Troubles Encountered with Carbon Brushes*

By E. H. Martindale

SYNOPSIS—The paper is divided into five sections, based on the location of the cause of the trouble: (1) field, (2) armature, (3) commutator, including brush rigging, (4) external electrical, and (5) external mechanical.

The characteristics of carbon brushes which commonly affect the operation are resistance, hardness, abrasiveness, coefficient of friction, contact voltage drop and heat conductivity. None of these terms needs explanation, but the writer wishes to emphasize the importance of not confusing hardness with abrasiveness. By abrasiveness is meant the scouring or cutting action of the brush. Relative hardness may be judged by cutting the brush with a pocket knife or by marking with it on paper, or if more accuracy is desired, a set of pencils from 2B to 8H will be an aid, as a pencil softer than the brush will mark it and one harder will scratch it. The hardest brush with which the writer is familiar has no abrasive action, while one of the softest has a decidedly abrasive action.

FIELD TROUBLES

As the field coils are connected in series or series parallel, a partial short-circuit may occur in one coil without materially affecting the heating of the coil. This is usually attended with severe sparking at one or two studs, although in a wave-wound machine the commutation may be little affected. This trouble can best be located by noting the voltage drop across each coil with a constant current through the coils. Similar trouble may be caused by an error in rewinding a field coil. On some machines the shunt fields are connected with two or three fields in series and two or more of these groups in parallel. A partial short-circuit in one coil will then affect the entire group, electrically unbalance the machine, and cause heavy short-circuit currents.

In a cumulative compound machine one series field may be reversed accidentally and, as the load increases, sparking will occur usually at two adjacent studs; or the entire series field by mistake may be connected to oppose the shunt field, which will result in blackening of the commutator, with severe sparking at heavy loads. The best way to detect this is to excite separately the shunt and the series fields, being sure that the current flows in the same direction as when the machine is in operation. The polarity of each pole should be tested with a compass and should reverse as the compass is passed from one pole to the next. Furthermore, the polarity of each should be the same when either field is excited. In a generator the voltage will decrease and in a motor the speed will increase as the load increases.

Unequal air gaps are responsible for much commutation trouble. If one pole face is nearer the armature the flux across the gap is greater and a higher voltage will be developed in the coils under that pole. This may result in heavy short-circuit currents between the studs adjacent to that pole and other studs of the same polarity.

ARMATURE

An open circuit in an armature coil causes the most vicious form of sparking, accompanied by pitting of the mica between the commutator bars connected to this coil and the adjacent ones. The usual method is to connect an incandescent lamp in a testing circuit, and with two pointed terminals make a bar to bar test on the commutator; the open circuit is shown when the lamp does not light. Similar sparking in a lesser degree may be caused by a high-resistance connection between the end of a coil and the commutator riser. This can be detected by passing a current through the armature and noting the voltage drop between adjacent bars, as the voltage will be higher than normal when the poor connection is in the circuit measured. This method may also be used to detect an open circuit, but a voltmeter reading as high as the voltage impressed on the armature must be used.

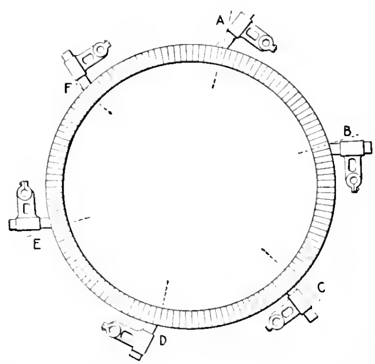
A short-circuit between two sections of a coil, two coils in the same slot, the end connections of two coils, or between the commutator bars, will be evidenced by excessive heating of the coils affected, and unless repaired will sooner or later result in a burned-out coil. The same method may be used as in the preceding case, and the voltage between adjacent bars when the coil is in the circuit will be below normal.

The demagnetizing and cross-magnetizing actions of an armature have serious effects on the commutation of many machines. To get good commutation in a non-interpole machine, the brushes usually must be set ahead of the mechanical neutral on a generator and back of the mechanical neutral on a motor.

If the brushes are shifted far to obtain good commutation, and if the magnetization of the polepieces is not well above the knee of the saturation curve, the demagnetizing effect of the armature may seriously reduce the voltage of a generator or increase the speed of a motor. On the other hand, the cross-magnetizing effect may be sufficient, if the brushes are not shifted to the electrical neutral, to place the coils undergoing commutation in a heavy field, with resultant heavy short-circuit currents, severe sparking at the brushes and all the attendant evils. The remedy is to widen the neutral field by filing away the edges of the polepieces.

COMMUTATOR

Commutator-brush troubles are numerous, and often difficult to identify. One of the most troublesome problems with non-interpole generators or motors which do not operate at constant load is the difficulty of finding a point at which the brushes will operate at all loads without injurious sparking. This is due to the cross-magnetizing action described.



Unequal Spacing Due to Brush-Holders Being Rotated Too Far

Spring tension, or the pressure with which the brushes bear on the commutator, seldom receives proper attention. The most economical pressure is the lowest consistent with a low contact loss, a clean commutator and freedom from sparking, glowing or pitting of the brushes. It is seldom advisable to use a pressure less than 1½ lb. per sq.in. of cross-section. The writer recommends on stationary machines a pressure of from 2 to 4 lb., depending on local conditions and the grade of brush; and from 4 to 8 for crane motors, haulage motors, railway motors and similar machines.

Brush spacing is important, but is usually neglected. In the sketch the studs are equally spaced and the dotted lines show the correct brush position, but owing to the brush holders on arm A being rotated too far in one direction and on arm C too far in the opposite direction, the voltage generated in section ABC is different from that in AFE or CDE, and this will result in short-circuit currents between A, E and C, high enough to neutralize the unequal voltage.

The magnitude of this short-circuit current may be illustrated by a test conducted a few years ago by the writer on a 400-amp., 250-volt, six-pole shunt generator. On one positive stud the brush holders were rotated to place the brush ¾ in. ahead of the correct position; the other positive studs were left unchanged. With the brushes incorrectly

*Excerpts from paper read before the Cleveland Section, A. I. E. E., March 18, 1915.

spaced but operating at the best point, the short-circuit current was not excessive. When the brushes were shifted two bars away from the neutral and with no external load on the machine the short-circuit current rose to 800 amp., or twice the normal full-load current. As the voltage back of this current was low the actual power loss was small, but the heating of the windings and the effect on the commutator and brushes were serious. This is an extreme case, but a smaller difference in spacing may often be serious.

From the time a commutator bar touches one edge of a brush until it leaves the opposite edge, the current in the coil undergoing commutation should fall from full load to zero, and rise in the opposite direction to full load. If the current in the coil is more or less than that value, the final adjustment comes as a sudden rush of current as the bar leaves the brush. In many machines the time of commutation is less than 0.001 sec. The brushes should therefore be shifted to a point where the coils undergoing commutation are in a field strong enough to make this change. If the brushes are too thin, sufficient time is not allowed for commutation, and if too thick, the coil may over-commutate.

If there is not sufficient clearance between a brush and its holder or if foreign matter becomes lodged in the holder, the brush will not move freely and may make poor contact, resulting in blackening of the commutator, sparking, heating and other evils.

On the other hand, if there is too much clearance and the brushes are not equipped with shunts, the current may pass from the brush to the brush holder through a small arc and cause undue wear of the holders. On machines which have been in service a long time trouble frequently arises from worn holders. This is particularly true if the machine runs in both directions, as the brush face changes when the machine is reversed and thereby reduces the time of commutation and increases the current density in the brush faces. Brushes in worn holders are also more inclined to chatter and chip.

Brushes are sometimes ordered longer than standard with a view to securing a long life, but the spring usually gives a side push and causes trouble, which shortens the life of the brushes and perhaps damages the commutator.

Noise of carbon brushes is due to a mechanical vibration called chattering. If due to the friction of the brush on the commutator, the noise may have various pitches. The remedy is a change in spring tension, angle of operation or grade of brush, although relief may be obtained by lubrication of the commutator at intervals. If the noise results from high mica or wide slots in a slotted commutator, the pitch of the sound will correspond to the number of bars passing under the brush in a second. If the noise is caused by slots, it may be necessary to change the spring tension, the angle of operation, or grade of brush, as lubrication is not advisable on a slotted commutator.

Pitting or honeycombing of the brush faces is nearly always caused by short-circuit currents or a very low brush pressure, but occasionally it is due to insufficient current carrying capacity of the brushes. Many cases of pitting may be corrected by reducing the thickness of the brushes, but it is better to look for some other cause first, as already described.

A loose commutator bar may be flush with other bars when the machine is stationary, but may be thrown out slightly when running, owing to centrifugal force. This will lift the brush and will burn one or more bars just ahead of the high bar, depending on the number which the brush spans, and further, will burn some of the bars back of the high bar, depending largely on the speed of the machine and the brush pressure. Its presence can often be detected by the knocking sound of the bar hitting a brush once every revolution.

In repairing commutators and sometimes in manufacturing them, commutator bars of different hardness are used, and one bar may wear faster than another, causing a flat spot or a high bar.

Blackening of a commutator may be caused by sparking, the use of too much lubricant, or by the character of the brush. Blackening will sometimes occur on every alternate bar or every third bar, corresponding to the number of coils per slot, and may often be shifted to another group of bars by shifting the location of the brushes. This seems to be due to a magnetic kick in the coil undergoing commutation when the armature tooth next to the coil suddenly leaves the field. The remedy is to have the neutral field wide enough to permit the tooth to leave the strong field before the commutator bar comes under the brush.

The best practice in commutator slotting consists in undercutting the mica about 3/64 in. below the surface of the commutator. It is important that great care be exercised to see that all the slots are free from strips or particles of mica flush with the commutator. It is not advisable to use lubricant or artificially lubricated brushes on a slotted commutator, as the lubricant may get into the slots, collect dirt and cause short-circuits between bars. On slow-speed machines, where the peripheral speed is not sufficient to throw out particles of dirt, the commutator slots should be blown out or scraped out at regular intervals. On a slotted commutator a brush with no abrasive action may be used and will result in long life of the commutator and brushes. A non-abrasive brush or a self-lubricating brush does not necessarily mean a soft brush.

Heating of the commutator on a machine may be caused by any form of sparking, short-circuit currents, friction of brushes, high brush pressure, too low brush pressure causing high contact loss, dirty commutator, overloads, too small commutator, resistance of windings, loose connections, eddy currents and hysteresis. As the ultimate capacity of a machine depends on the allowable temperature rise, it is important to prevent heating wherever possible.

OUTSIDE ELECTRICAL CAUSES

Outside electrical causes of commutation trouble may be briefly stated as overloads, line surges, and cross currents between two or more machines running in parallel. Where the angular speed of a reciprocating engine varies greatly, surges may occur, caused by a slight reduction in speed of motors on the circuit when the voltage is low and a consequent rush of current when the voltage reaches its maximum. It may be impossible to locate surges or cross-currents without the use of an oscillograph.

OUTSIDE MECHANICAL CAUSES

If an armature is mechanically unbalanced severe vibration may occur, especially if it is run at high speed. This may produce flat spots, unbalanced electrical conditions, loosening of commutator bars and other serious troubles.

If the machine is on unstable foundations similar troubles may be experienced, owing to vibration of the entire machine. In this class may be placed crane motors and similar machines which, however, are usually designed with this factor in view. Poor belt lacing or uneven gears may produce vibration or strain, with the same results.

Condenser-Tube Corrosion

The third part of the Institute of Metals' "Contributions to the History of Corrosion" has been issued. It consists of a contribution by Arnold Philip, Admiralty chemist, attacking the conclusions of G. D. Bengough and R. M. Jones, and a supplement containing their reply. An abstract of the first two parts appeared in "Power," Dec. 2, 1913, page 781.

We do not reproduce the third part at length, as it seems largely to reinforce Bengough and Jones' original work and conclusions, namely, that entrained pieces of coke are not grave causes of condenser-tube corrosion. Some of their minor points concerning the technique of their experiments may, however, be of interest.

The point is made that the method of determining loss of weight is of little use in investigating corrosion. Of all failures, 90 per cent. "are caused by local dezincification, and when once this has been started loss-of-weight methods are useless. The action was quite local and irregular, and the white zinc salt was strongly adherent and usually could not be removed without injury to the underlying oxide layer."

The authors conclude that, consequently, a means of detecting dezincification is the only rational way of detecting the progress of corrosion. Here they leave us at sea. The only method available giving actual measurement seems to be microscopic investigation, especially of sections cut at right angles to the supposed dezincified spot. This involves destruction of the specimen. The next best is a hardness test by rubbing with a blunt steel needle, the dezincified area being softer than the unchanged brass. In fresh specimens the eye with proper training can detect the dezincified spots, even in the early stages; in old specimens the copper oxidizes, and this copper cannot be told from the ordinary oxide layer.

Another point made is that when various plates of metal are being tested for resistance to corrosion it is not fair to take pieces of tube and flatten them, or clean them, or anneal, or in any other way alter the normal skin of the metal. After attention has been called to this it seems self-evident, yet we have known cases where it has not been observed.

Another point spoken of is that sea water to which sufficient sodium carbonate has been added to make it alkaline in reaction instead of neutral, as is normal sea water, is much more active in producing dezincification than the normal sea water. Here is a practical point in condenser practice.

St. Louis Consumers Protest against Rates

The Engineers' Incitation Club, representing consumers of electricity in St. Louis, has filed a petition with the public-service commission of Missouri, protesting against the alleged discriminatory rates charged by the Union Electric Light & Power Co., of that city. The present maximum rate to small consumers is 10c. per kw.-hr., whereas it is charged that certain large consumers pay less than 1c. per kw.-hr. The petitioners would have the rate fixed at a maximum of 5c. per kw.-hr. for the first 120 hr. of installed capacity used per month, with all in excess thereof at 2½c. per kw.-hr.

It appears that the Union Electric Light & Power Co. procures a large portion of its supply from the Keokuk hydro-electric development. This power is generated by the Mississippi River Power Co., but instead of purchasing direct from this company the defendant buys through intermediary companies known as the Mississippi River Power Distributing Co. and the Electric Co. of Missouri. It is alleged that these corporations are under common control and through collusive agreements are defeating the purpose of Congress in making the water-power grant, and instead of the public being the beneficiaries of low rates, a few promoters and stockholders in the companies mentioned are reaping the benefit.

ENGINEERING AFFAIRS

American Association of Refrigeration Meeting—The fifth annual meeting of the American Association of Refrigeration will be held at the Hotel Astor, New York City, May 11 and 12. There will be important reports from officers and standing committees and commissions of the association, including a detailed financial statement of the Third International Congress of Refrigeration.

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold its next meeting June 17 and 18, at Toledo. Plans are being made for an outing, together with the regular reading and discussion of papers. Among papers to be given are: "Firebricks for Boiler Settings," by W. G. Heisel; "Some Features of the Cleveland Municipal Lighting Station," by F. W. Ballard; "Low-Pressure Turbines," by a representative of the General Electric Co., and "Attainment and Maintenance of Boiler-Room Efficiency," by a representative of the Harrison Safety Boiler Works.

The American Boiler Manufacturers' Association and the National Tubular Boiler Association at a joint meeting held in Pittsburgh on Mar. 29 unanimously approved the Code of Boiler Specifications prepared by the committee appointed for that purpose by the American Society of Mechanical Engineers, and steps were taken toward securing its adoption by the various states. Several of the members and the representative of a prominent boiler-insurance company declared that they should adopt it as their standard, whether compelled to by legislation or not.

The National Gas Engine Association is to hold its annual meeting on June 23 and 24 at the La Salle Hotel, Chicago. Reports will be presented by the Standardization, Insurance, Cost Accounting, Legislative and Publicity committees. The following papers are scheduled: "The Data Work," by Prof. P. S. Rose; "Educating the Buyer to Your Type of Engine," by H. G. Diefendorf; "Possibilities of the Farm Lighting Plant," by C. H. Roth; "What of the Kerosene Engine?" by C. E. Bement; and papers by unannounced speakers on "The Future Work of the Association," "How Dealers May Be Induced to Buy for Cash" and "The Magneto of the Future." An accessory exhibition will be arranged, space in which can be secured by addressing the secretary, H. R. Brate, Lakemont, N. Y.

NEW PUBLICATIONS

COAL GAS RESIDUALS. By Frederick H. Wagner. Published by the McGraw-Hill Book Co., 239 West 39th St., New York, 1915. Cloth; 179 pages; 6x9 in. Price, $2.

Convinced that, even under normal conditions, the recovery of coal-gas residuals is an important means of conserving our natural resources, Mr. Wagner has described German theory and practice in recovering coal gas byproducts and has given estimates of initial and operating costs and of the possible income from the production of tar, naphthalene, cyanogen, ammonia and benzol. Coke is not considered, but is to be treated in a separate volume. Most of the methods outlined were devised by the German chemist Feld, and relate to installations in Germany. Unfortunately, no photographs are given, but the book is illustrated by drawings of the different apparatus required.

BOOKS RECEIVED

PRACTICAL IRRIGATION AND PUMPING. By Burton P. Fleming. John Wiley & Sons, Inc., New York. Cloth; 226 pages, 5½x8¼ in.; 27 illustrations; tables. Price, $2.

HEATING AND VENTILATING BUILDINGS. By R. C. Carpenter. John Wiley & Sons, Inc., New York. Cloth; sixth edition; 598 pages, 6x9¼ in.; 290 illustrations; tables. Price, $2.

HEAT ENGINEERING. By Arthur M. Greene, Jr. McGraw-Hill Book Co., Inc., New York. Cloth; 462 pages, 6x9½ in.; 198 illustrations. Price, $4.

CENTRIFUGAL PUMPS. By R. L. Daugherty. McGraw-Hill Book Co., Inc., New York. Cloth; 192 pages; 6x9½ in.; 111 illustrations; tables. Price, $2.

VOCATIONAL MATHEMATICS. By William H. Dooley. D. C. Heath & Co., New York. Cloth; 341 pages; 5x7½ in.; illustrated; tables. Price, $1.

TRADE CATALOGS

McNab & Harlin Mfg. Co., 55 John St., New York. Bulletin. Brass fittings. Illustrated, 5x7 in.

Trill Indicator Co., Corry, Penn. Booklet. Outside spring engine indicator. Illustrated, 16 pp., 6x9 in.

The Scranton Pump Co., Scranton, Penn. Bulletin No. 101. Duplex piston pumps. Illustrated, 16 pp., 6x9 in.

Armstrong Cork Co., Pittsburgh, Penn. Folder. Nonpareil high-pressure covering for boilers, etc. Illustrated.

"Gripwell" Pulley Covering Co., Candler Building, New York. Folder. Gripwell pulley covering. Illustrated.

The Lagonda Mfg. Co., Springfield, Ohio. Catalog W-1. Lagonda locomotive arch tube cleaners. Illustrated, 12 pp., 6x9 in.

York Mfg. Co., York, Penn. Booklet. Ice-making and refrigerating machinery, ammonia fittings and supplies. Illustrated, 20 pp., 6x9 in.

Automatic Steam Trap & Specialty Co., Detroit, Mich. Catalog No. 8. Barton expansion automatic steam trap. Illustrated, 16 pp., 3½x6 in.

Hercules Float Works, 200-10 Franklin St., Springfield, Mass. Catalog. Seamless copper floats and air chambers. Illustrated, 8 pp., 4x8½ in.

Harbison-Walker Refractories Co., Pittsburgh, Penn. Catalog. Silica, magnesia, chrome and fire clay brick, etc. Illustrated, 160 pp., 4x6½ in.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. Bulletin R. A. Richards unloaders for air compressors. Illustrated, 8 pp., 6x9 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-M. Class O steam and power driven compressors. Illustrated, 36 pp., 6x9 in.

BUSINESS ITEMS

Swift & Co., Chicago, Ill., have recently placed an order with the Builders' Iron Foundry, Providence, R. I., for an extra heavy 4-in. Venturi meter tube with type M register-indicator-recorder for use on their boiler feed service.

The Ingersoll-Rand Co., 11 Broadway, New York, has just issued Form 3015, "Portable Air Compressors," which is a 32-page illustrated treatise on the subject of portable air-compressing outfits. Copies are mailed free on request.

The American District Steam Co., of North Tonawanda, N. Y., has opened offices at Suite 610, West Street Building, 140 Cedar St., N. Y. This office will be in charge of G. C. St. John, formerly president of the New York Steam Company.

The Elliott Co., 6908 Susquehanna St., Pittsburgh, Penn., has published two new leaflets of interest to power-plant men, one on twin oil strainers, type "U," and the other (Bulletin J) on pump governors. Copies will be sent on application to the company.

J. G. De Remer, member of the American Society of Mechanical Engineers, American Institute of Electrical Engineers, and formerly chief mechanical and electrical engineer of the United Light & Power Co., San Francisco, has been made manager of the general engineering department of the American District Steam Co., of North Tonawanda, N. Y.

The Canadian Fairbanks-Morse Co., Ltd., has been appointed selling agent in Canada for Penflex metal hose, manufactured by the Pennsylvania Flexible Metallic Tubing Co., Broad and Arch St., Philadelphia. The Canadian Fairbanks-Morse Co. has branches in 14 of the largest cities of Canada, and will carry a complete stock of Penflex in different sizes and styles at its different warehouses, so that Canadian consumers will have the same service as purchasers on this side of the boundary.

POWER

Vol. 41 NEW YORK, APRIL 27, 1915 No. 17

The Old Standby

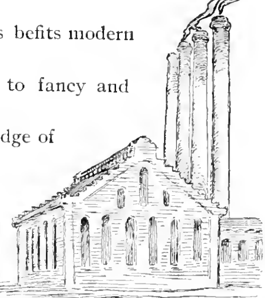
By R. T. Strohm

SUNDAY SUPPLEMENTS often attract
our attention
By printing, with scareheads two inches
in height,
An extended account of some splendid invention
Whose wonderful value has just come to light.
We are calmly assured that, for turning out
power,
This latest contraption will soon be supreme,
But its memory lives for a day or an hour,
And still we rely on the pressure of steam.

Just as likely as not, it's a new style of turbine,
Designed to be run by the ambient air,
And adapted for service in regions suburban,
In cities, in deserts, and most anywhere;
Or if not, it's a waterwheel, complex and weighty,
Intended to turn in the rush of a stream,
With a total efficiency far above eighty—
Yet still we depend on the power of steam.

Now and then it's a form of perpetual motion,
Producing its energy quite without cost,
Or perhaps it's a wave motor set in the ocean
To harness the forces that long have been lost.
And our minds are amazed at the marvels of
science
Displayed in each clever, ingenious scheme,
But we pass them all by, and we pin our reliance
On motors deriving their power from steam.

We are told that the gas engine sooner or later
Will drive out the type that we credit to Watt,
But as gas-fuel prices grow steadily greater,
Deep down in our hearts we are sure it will
not.
So we dig out our books, as befits modern
toilers,
And leave the romancer to fancy and
dream,
While we add to our knowledge of
engines and boilers,
Convinced that there's
always a future for
steam.



Diesel-Engine Central Station at Winchester, Ind.

By Thomas Wilson

SYNOPSIS—A 400-kv.a., two-unit plant generating current for light and power and the pumping of city water. Fuel costs less than 1/4c. per kw.-hr. The operating cost is 0.457c., and including overhead, the total cost is 0.96c. per kw.-hr.

In the past few years the Diesel engine has made rapid progress, and it is now generally conceded that there are certain fields in which it excels. Where oil can be bought at a reasonable figure, these engines, as now made, show remarkable results. The initial expense is high, but this is offset by an operating cost so low that the total per unit of output will fall below that of the average steam plant. There are no stand-by losses, and with proper care, maintenance is no higher than with steam. The engine may be brought into service on short notice, and the labor required to operate is less than would maintain a steam plant of equal capacity. In plants under 1000 hp., such as would be employed in small factories or for the lighting of small towns, the Diesel engine is at its best.

An interesting example of a small central station tending to prove the above assertions may be found in Winchester, Ind., which has a population of 5100. The plant, which is operated by the Citizens Heat, Light & Power Co., contains two 200-kv.a. units, furnishing commercial and street lighting for Winchester and four adjacent towns. Power service is supplied over the same circuits, and at the station, current for pumping water to the home town and to run the air compressors serving the prime movers. Three-phase current is generated at 2300 volts. During the day one unit will carry the load, which runs up to 160 kw. At the peak, which lasts from 5 to 10 p.m., the load is practically double, and in the morning hours it is comparatively light. It is thus evident that one machine must be operated continuously and the other for five hours, the two running in parallel. During the latter period there is no reserve unit. Both machines must operate every day, and for the past two years and three months, during which they have been in service, this schedule has been maintained without a shutdown.

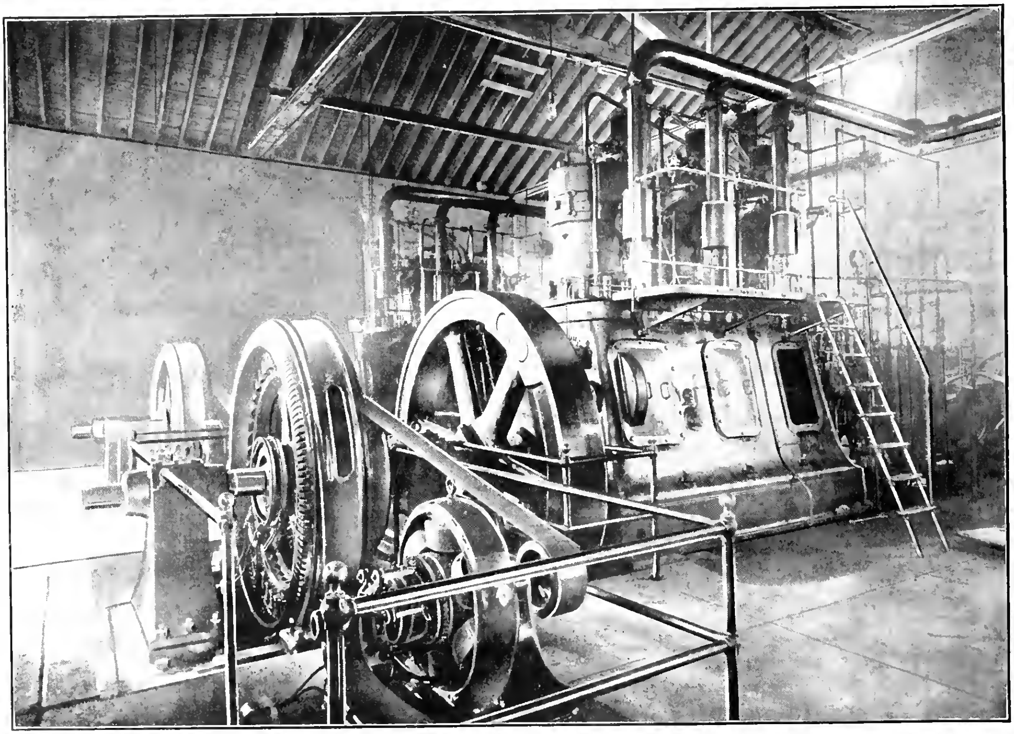


Fig. 1. Diesel-Engine Units

The engines are of the three-cylinder vertical type, 16x24 in., with a speed of 165 r.p.m. They are rated at 225 hp. and are connected directly to 200-kv.a., three-phase, 60-cycle generators, which, at 80 per cent. power factor, will deliver 160 kw. As shown in Fig. 1, the exciters are belted to the shaft. The latter machines are rated at 11 kw. and are driven at a speed of 600 r.p.m. The two units are exact duplicates.

Air for fuel injection and starting is supplied by two three-stage, motor-driven air compressors and is stored at a pressure of 60 atmospheres, in 10 steel bottles. This is equivalent to 882 lb. per sq.in., and on heavy loads the pressure is run up to 955 lb. When only one engine is running, the smaller compressor, which has cylinders 8, 5 and 2⅜ by 8 in., is operated. This machine is belt-driven by a 25-hp. induction motor. The other compressor, which has cylinders 10, 6½ and 3 by 12 in., is large enough to serve the two engines, and is operated during the peak load. It is belt-driven by a 50-hp. induction motor.

Jacket water is drawn directly from the mains and is returned to the reservoir, located near the plant. As a large quantity is used for this purpose, the rise in temperature is small, so that no lime is deposited in the jackets.

Fuel is stored in an underground oil house located between the plant and the railway. It has two 8000-gal. tanks, which are filled by gravity from railway tank cars. An interesting method was used when installing these tanks. Everything, including the foundation, was made ready for their support. The pit was then filled with water and the tanks rolled into the opening. As the water was pumped out, they gradually settled and were guided into place with little difficulty.

From the underground storage two elevator tanks in the engine room are filled with oil by a motor-driven pump, or by a hand pump which has been provided to guard against emergencies. From this elevated location on the engine-room wall, the oil flows by gravity through a strainer to the fuel pumps, which force it up to the

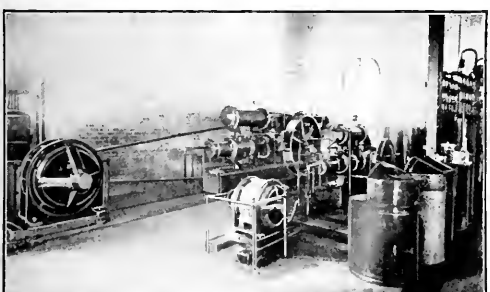


FIG. 2. MOTOR-DRIVEN, THREE-STAGE COMPRESSOR

fuel valves. A meter attached to each engine measures the quantity of oil in gallons, and a gage shows the pressure in the air line.

The plant is equipped with an uptodate switchboard consisting of nine gray-slate panels, carrying horizontal edgewise ammeters and voltmeters, polyphase integrating wattmeters, induction watt-hour meters on the different circuits, a synchronizing indicator, a power-factor indicator and a Tirrill voltage regulator. The switches and copperwork are standard throughout.

Water for the City of Winchester is obtained from a reservoir on the premises, which is supplied from seven 8-in. wells 190 ft. deep. A pressure of 45 lb. is maintained on the system, and in case of fire it may be run up to 95 lb. To supply this water, three triplex power pumps are installed in the station. Two of these have a capacity of 250,000 gal. each per 24 hr. One is driven by a synchronous motor which has double the capacity needed and is over-excited to raise the power factor on the electrical system. The other is driven by a 40-hp., 8x12-in., three-cylinder gas engine. A large fire pump of the same general design, driven by an induction motor, is also installed. Its capacity is 450,000 gal. per 24 hr. Ordinarily, one of the smaller units will supply the demand for water. In case of fire the second small unit, or the fire pump, which is large enough to supply all requirements may be started. Natural gas from a

FIG. 3. SWITCHBOARD

commercial pipe line is used in the gas engine. An additional source of power is thus afforded that will tend to prevent a shutdown should anything happen to the electrical plant.

COST OF THE EQUIPMENT

Table 1 gives the cost of the generating equipment as entered on the company's books. The engines, air compressors and everything required for their operation cost $29,000; the generating equipment, $5000; foundations

TABLE 1. COST OF GENERATING EQUIPMENT

Engines and air compressors	$29,000
Generators	5,000
Foundations and installation	2,000
Switchboard	6,000
Building and oil tanks	10,000
Total	$52,000
Rated engine horsepower	450
Generating capacity, 80% p.f., kw	320
Cost per horsepower	$115.55
Cost per kilowatt	$162.50

TABLE 2. OIL USED AND COST PER UNIT

Months	Kw.-Hr.	Gal. Oil	Oil per 100 Kw.-Hr., Gal.	Cost of Oil at 3c.	Fuel Cost per Kw.-Hr. Cents
November, 1914	107,270	8,280	7.7	$248.40	0.2316
December, 1914	119,560	9,250	7.7	277.50	0.2321
January, 1915	94,010	8,930	9.5	267.90	0.2849
Totals	320,840	26,460	8.2	$793.80	0.2474

and installation, $2000; making a total of $36,000. Per kilowatt of generating capacity, this reduces to $112.50. Adding to the above total the cost of the switchboard, the building and the oil-storage tanks, gives a total of $52,000, or $162.50 per kilowatt of generating capacity. Compared to the cost of a steam plant per unit of generating capacity, this is high. Interest and depreciation on this figure naturally handicap the plant, but are more than offset by the low operating cost.

Data taken from the log book for the three months previous to the writer's visit show that the load averaged over 100,000 kw.-hr. per month. The quantity of oil used averaged 8.2 gal. per 100 kw.-hr., which is a trifle under

0.6 lb. per kw.-hr. The fuel oil used ranges in density from 32 to 34 deg. Baumé and its cost delivered in tank-car lots was 3c. per gal. Dividing the total cost of the oil by the total output in kilowatt-hours, the average fuel cost for the three months was 0.2474c. per kw.-hr. This is much less than in an average steam plant of the same capacity.

Table 3 gives the operating, overhead and total costs

TABLE 3. GENERATING COST AT SWITCHBOARD

		C. per Kw.-Hr.
Fuel at 3c. per gal.		$0.2474
Labor: One chief engineer, $75 per mo.; One assistant engineer, $60 per mo.; One night engineer, $60 per mo.	$195	0.1823
Maintenance per month, $926		0.0086
Supplies, lubricating oil, waste, etc., $20 per month		0.0187
Operating cost		$0.4570
Overhead: Interest, depreciation and taxes, 12½% on $52,000		0.5065
Total cost		$0.9635

of power generation. It will be noticed that only three men are required to run the plant continuously, but during the writer's visit two were carrying on the work, an accident to the chief engineer having kept him away.

PRINCIPAL EQUIPMENT OF WINCHESTER OIL ENGINE PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Diesel	3-cyl., 16x24-in.	Generating units	32-34 deg. oil, air 60 atm., 165 r.p.m.	Busch-Sulzer Bros. Diesel Engine Co.
2	Generators	Three-phase, 60-cycle	200-kw.	Generating units	2300-volt, direct-driven by Diesel engines	(Fort Wayne) General Electric Co.
2	Generators	Direct-current	11-kw.	Exciter	125-volt, 600 r.p.m., belt-driven	(Fort Wayne) General Electric Co.
2	Air compressors	Three-stage	8x5x2¾x8-in. 10x6½x3x12-in.	Air for Diesel engines	60 atm., belt-driven by induction motors	Ingersoll-Rand Co.
1	Pump	Triplex	7⅞x12-in.	Pump city water	Chain-driven by Fort Wayne synchronous motor	Goulds Manufacturing Co.
1	Pump	Triplex	7⅞x12-in.	Pump city water	Driven by 40-hp. Nash gas engine	Goulds Manufacturing Co.
1	Pump	Triplex	11x12-in.	Pump city water	Driven by 50-hp. independent motor	Goulds Manufacturing Co.
1	Pump	Centrifugal	1-in.	Oil from storage to tanks in engine room	Driven by 1-hp. motor	Chas. S. Lewis & Co.
1	Hand pump		1-in.	Oil from storage to tanks in engine room		Trahern Pump Co.
2	Meters	Integrating		Measures oil to engines		National Meter Co.
2	Gages	Indicating		Pressure in air line		Schaeffer & Budenberg Mfg. Co.
4	Lubricators	Force feed	Three feeds	Lubricate cylinder of engine and air compressor		
	Switchboard and all instruments					General Electric Co.

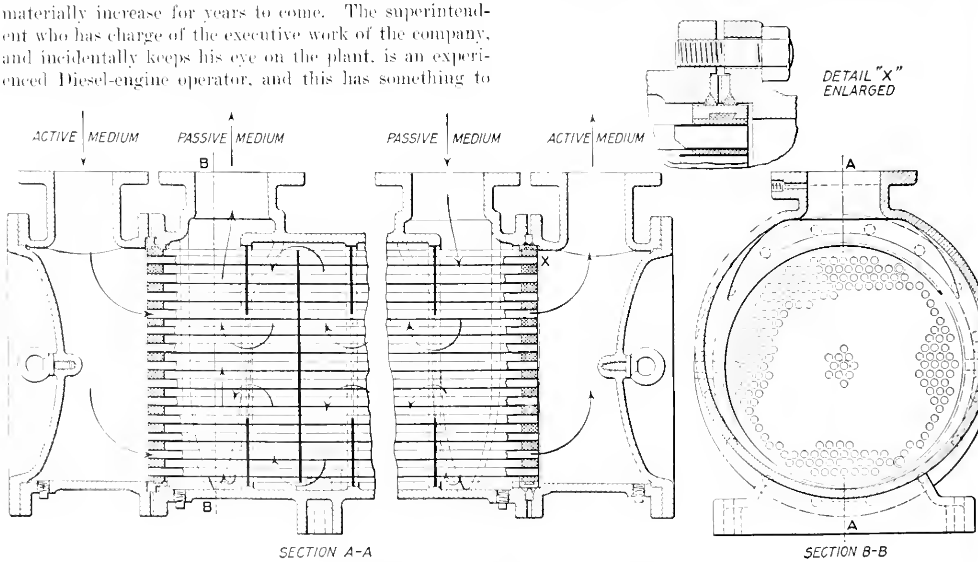
The two Diesel-engine units were started Dec. 1, 1912, and during the 27 months of operation about $250 has been expended for maintenance. The equipment is, of course, new, but indications are that this item will not materially increase for years to come. The superintendent who has charge of the executive work of the company, and incidentally keeps his eye on the plant, is an experienced Diesel-engine operator, and this has something to do with the maintenance item. Lubricating oil, waste and supplies averaged $20 per month. The sum of the various operating items is only 0.457c. per kw.-hr., and when an overhead of 12½ per cent. is added, the total is below 1c. per kw.-hr. delivered to the switchboard. This showing is exceptional for a small plant, and if the load should increase up to the capacity of the generating units, the overhead cost per unit will be reduced, which in turn will lower the total operating cost appreciably.

To O. N. Eiler, superintendent of the company, we are indebted for the information contained in this article.

The S. & K. Oil Cooler

The essential feature of the S. & K. oil cooling apparatus is its high efficiency, which is attained by the arrangement of the cooling surface and the method used to pass two mediums through the apparatus, exchanging the heat through the tube walls in counter currents. As the thickness of the tubes has considerable influence on the heat condition, comparatively thin walls are used, which also make a saving in weight and space.

The tube sheets of the apparatus are built of metal in which the tube ends are cast, and therefore the spacing and the shape of the tube may be so chosen as to give



DETAILS OF THE S. AND K. OIL COOLER

the best results in heat transfer, instead of being determined by the strength of metal required for expanding, rolling or inserting of the tube end and spacing the tubes.

This oil cooler serves the purpose of removing the heat from the lubricating oils used on bearings and can be used in any forced lubricating system. The arrangement consists of a continuous circuit in which the oil is taken by pumps from the bearings and forced through the apparatus, where it is cooled and then returned to the bearings.

In order not to block the supply of cooled lubricant coming from the machine, the hot oil is removed quickly and rapid circulation is obtained, which is a factor in cooling the bearings.

The illustrations show an important part in the construction of the cooler. The arrangement of packing prevents any mixing of the oil and water, and any leakage will come to the surface and be at once detected. The apparatus requires a small pump for water, which keeps down initial cost and operating expenses. The water passages can be cleaned by removing the cover without disconnecting any pipe, and the whole tube bundle can be withdrawn to inspect the outside of the tubes. The oil cooler can be used in any position, but it is better to use it in a vertical one, as the flow of both water and oil is more uniform, and any sediment in the oil will settle at the bottom and is easily removed.

The appliance is manufactured by the Schütte & Koerting Co., 12th and Thompson St., Philadelphia, Penn.

The Specific Heat and Heat of Fusion of Ice

By H. C. Dickinson and N. S. Osborne

Results of previous determinations of the specific heat of ice by certain observers have indicated a rapid increase in the specific heat on approaching the melting point, whereas A. W. Smith* has found the heat capacity of ice to be practically constant up to temperatures close to zero.

The present investigation has been undertaken with the object of securing further evidence as to the thermal behavior of ice at temperatures near the freezing point and of obtaining reliable data for the construction of tables of the total heat of ice and water in the range of temperature with which refrigerating engineers are concerned.

The measurements were made by means of a calorimeter of aneroid type, i.e., without stirred liquid as calorimetric medium. The samples used were from 400 to 470 grams each. Three were of redistilled water of fairly high purity, while a fourth, which was distilled directly into the container, appeared from the experimental results, to have a much higher degree of purity.

In the determinations of specific heat it is found that over the range of temperature covered by the experiments (—40 to —0.05 deg. C.), the specific heat S in 20-deg. calories at any temperature θ of the four ice samples is represented within the limit of experimental error by the equation

$$S = 0.5057 + 0.001863\,\theta - 79.75\,\frac{l}{\theta^2}$$

in which the constant l is assumed to represent the initial freezing point of the specimen and has the following value: Sample No. 1, —0.00125 l; No. 2, 0.00120 l; No. 3, 0.00095 l; No. 4, 0.00005 l.

[The large calorie, or French heat unit, is usually taken as the amount of heat required to raise one kilogram of water one degree Centigrade, or from 15 to 16 deg. C. The "20-deg. calorie" as used by the authors means the heat necessary to raise one kilogram of water one degree Centigrade at 20 deg. C. instead of at 15 deg. C.—Editor.]

From the fact that the term which represents the departure of the specific heat from a linear function of the temperature is found to depend on the purity, being less the higher the purity of the ice, it is concluded that the specific heat of pure ice in 20-deg. calories may be closely represented by the equation

$$S = 0.5057 + 0.001863\,\theta.$$

Determinations of the heat of fusion made upon three of the samples used for the specific-heat determinations gave the following values: Heat of fusion of sample No. 1, 79.68 cal.; No. 2, 79.85; No. 4, 79.75; mean, 79.76 cal.

The results of a previous investigation at the Bureau of Standards using different methods to determine the heat of fusion of ice give, when corrected for the newly found value for specific heat, a mean value of 79.74 20-deg. calories.

The mean for the two investigations is 79.75 20-deg. calories per gram.

For the use of engineers a table of total heats of ice and water is given, expressed in B.t.u. per pound at temperatures from —20 to +100 deg. F.

TABLE OF TOTAL HEAT OF ICE AND WATER

Temperature of Ice t Deg. F.	Difference in Total Heat per Pound from Ice at t to Ice at 32 Deg. $H_{32}—H_t$ B.t.u per Lb.	Difference in Total Heat per Pound from Ice at t to Water at 32 Deg. $h_{32}—H_t$ B.t.u. per Lb.	Temperature of Water t′ Deg. F.	Difference in Total Heat per Pound from Water at 32 Deg to Water at t′ $h_t—h_{32}$ B.t.u. per Lb.
—20	23.8	167.2	32	0.0
—18	22.9	166.3	34	2.0
—16	22.1	165.5	36	4.0
—14	21.3	164.7	38	6.0
—12	20.4	163.8	40	8.1
—10	19.6	163.0	42	10.1
— 8	18.7	162.1	44	12.1
— 6	17.9	161.3	46	14.1
— 4	17.0	160.4	48	16.1
— 2	16.1	159.5	50	18.1
0	15.2	158.6	52	20.1
+ 2	14.3	157.7	54	22.1
4	13.4	156.8	56	24.1
6	12.5	155.9	58	26.1
8	11.6	155.0	60	28.1
10	10.7	154.1	62	30.1
12	9.7	153.1	64	32.1
14	8.8	152.2	66	34.1
16	7.8	151.2	68	36.1
18	6.9	150.3	70	38.1
20	5.9	149.3	72	40.1
22	5.0	148.4	74	42.1
24	4.0	147.4	76	44.1
26	3.0	146.4	78	46.1
28	2.0	145.4	80	48.1
30	1.0	144.4	82	50.1
32	0.0	143.4	84	52.1
			86	54.1
			88	56.1
			90	58.0
			95	63.0
			100	68.0

*Physical Review," 17, p. 193; 1903.

A Monster Aqueduct—The aqueduct conducting the waters of the Owens River, at Los Angeles, is said to be the largest in the world. It is designed to deliver a minimum of 258,000,000 gallons of water daily into the San Fernando reservoir, 25 miles northwest of the city. No pumping plant is required, as the source of supply is several hundred feet above the city. The water will furnish a great amount of power—7000 horsepower is anticipated—for electric lighting and other purposes. The total cost of the water-works will be $25,000,000, and the installation of the power plant will cost approximately $5,000,000 more.—"Exchange."

The Ridgway Steam Turbine

The steam turbine of the Ridgway Dynamo & Engine Co. is of the Rateau type and is built under license from Professor Rateau and C. H. Smoot, of the Rateau-Battu-Smoot Co., the American representatives of the professor. As our readers know from previous descriptions, the Rateau is a pressure-stage turbine, and is shown in conventionalized section in Fig. 2. Steam is expanded through the set of nozzles at the left, impinging upon the bladed wheels *EE*, the engraving showing some of the blades in section. The pressure drop in passing through each set of nozzles is sufficient to generate only a velocity which can be practically abstracted by the single row of buckets upon which the steam impinges in each stage.

With the first few pounds of drop in pressure the velocity generated is great in comparison with the increase one-third of that which would be generated by effecting the expansion in a single stage, 9 stages will be required; if one-fourth 16 stages; etc.

Fig. 1 shows this type of turbine, as built by the Ridgway Dynamo & Engine Co., connected with a 375-kw. alternator at the power plant of the Cascade Coal & Coke Co., at Tyler, Penn. This is a mixed-pressure machine designed for high-pressure steam of 125 lb. gage and exhaust steam of 16 lb. absolute pressure and runs at 3600 r.p.m. The low-pressure steam is the exhaust from reciprocating engine units, pumps, etc. By the installation of this unit the capacity of the power plant was increased 66 per cent. without any increase in the boiler plant, and with an actual decrease in the amount of coal consumed over the previous operating condition.

Fig. 3 is a section of the regular high-pressure type.

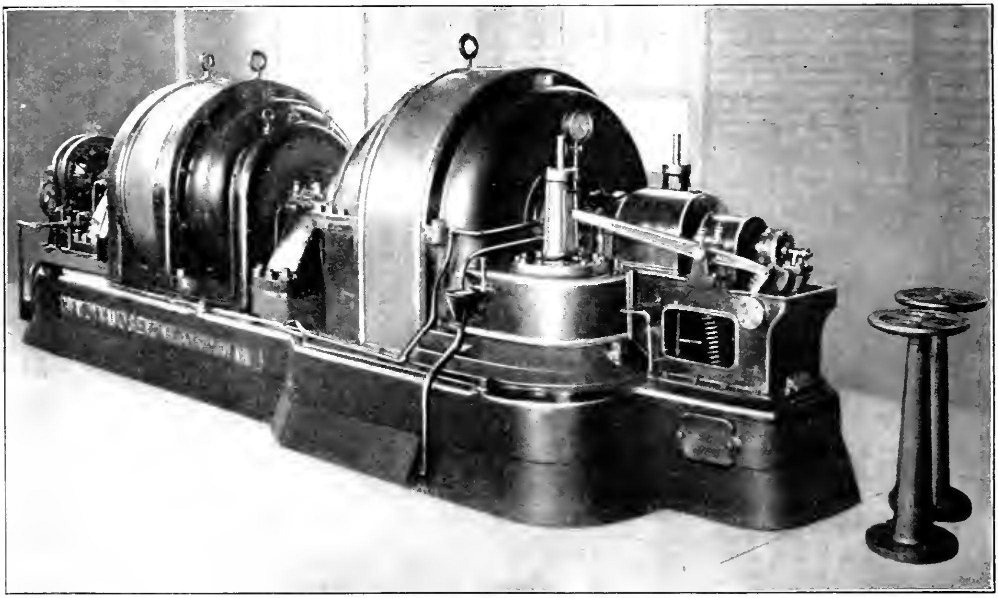


Fig. 1. 375-Kw. Ridgway Turbo-Driven Unit at Plant of Cascade Coal & Coke Co.

of volume, so that a smaller nozzle section is required to pass the same weight of steam. It is not until the lower pressure reaches about 58 per cent. of the higher that the volume begins to increase faster than the rate of flow necessary to take care of it, and the area of the nozzle necessary to pass it increases. As the pressure-drop in the Rateau turbine for the ordinary condition is well within this range, the nozzles are converging. Although the steam expands in going through them, the outlet is smaller than the inlet, as shown in Fig. 2. After having its velocity reduced by passing through the moving blades, the steam is discharging into a second series of nozzles, where it is further expanded, and so on until it is discharged to the condenser. The number of stages required for complete expansion varies inversely as the square of the velocity. If the velocity per stage is to be Steam enters at *A*, passes through seven sets of nozzles and bladed wheels having passages of ever-increasing section, and is finally discharged into the exhaust passage at the right. There are, therefore, eight different pressures existing in the machine, counting those of the steam chest and the exhaust passage, and the chambers containing these different pressures are divided by heavy partitions. But whatever the pressure in any chamber, it is the same on both sides of the wheel revolving in each chamber, so that, with the symmetrical buckets used, there is no end thrust, and all that is needed to keep the shaft in place and the nozzles and blades in their proper relations are the few thrust rings *RRR* in the bearing of the low-pressure end.

Fig. 3 shows the partitions in section, and it will be seen that they are heavier and more securely packed where the shaft passes through them, in the case of the high-pressure stages to the left, than in those at the right, where the pressure differences are less.

As the pressure is the same all around the wheel,

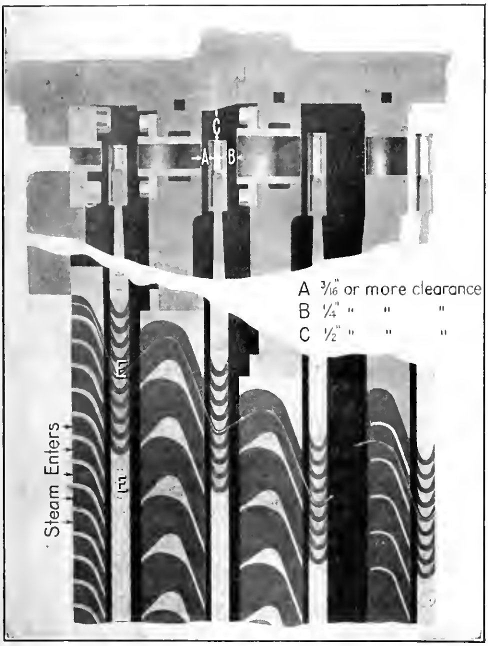


Fig. 2. Conventionalized Section of Nozzle and Blading

there is no tendency for the steam to leak by it, and the clearances, both longitudinally, as at A and B in Fig. 2, and radially, as at C in the same figure, may be comfortable and generous, the axial clearance even in small machines being $\frac{3}{16}$ and the radial ½ in. In large turbines these clearances are as much as ⅜ and 1 in., respectively.

The rotating element consists of a high-carbon steel shaft of such diameter that its normal speed is below the critical speed, and on which are turned the thrust rings referred to. The wheels are machined from disks of flange steel, and are keyed upon the shaft, being separated from each other by steel collars which run against the packing in the diaphragms which divide the stages. The buckets are machined from solid bars, the material selected, usually bronze, being adapted to the particular service for which the turbine or stage is designed. They are made in the

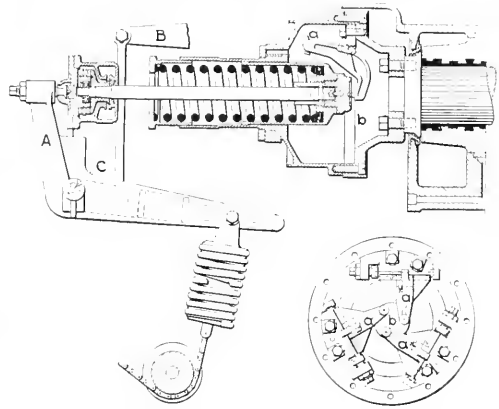


Fig. 4. Section and Details of Governor

two styles, Fig. 7, the smaller being secured by rivets through their shanks, so placed as to retain the maximum possible section, the larger with bulb ends which are driven into slots in the periphery of the wheel and peened solidly into place. Each bucket of either type carries its own shroud and, when assembled in the wheel, is in rigid contact at its outer end with the adjacent bucket, affording mutual support against vibration and damage.

The casing, the heads, and the diaphragms which separate the stages, are split horizontally, the top halves of the diaphragms being attached to the upper half of the

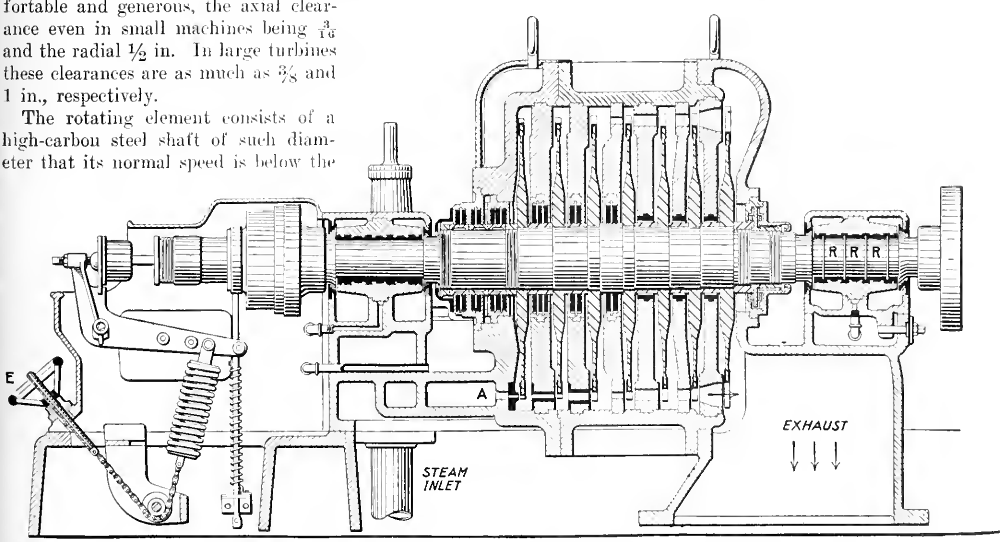


Fig. 3. Longitudinal Section Ridgway-Rateau Steam Turbine

casing and lifting with it. The steam and exhaust connections are made to the lower half, so that they need not be disturbed when the turbine is opened. The nozzles with small area for the initial stages are machined castings bolted into place, as shown in Fig. 5. In the later stages the blades forming the nozzles are cast in place in the diaphragm and extend all or part way around its periphery, as shown in Figs. 6 and 7.

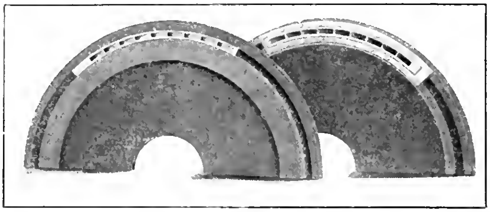


Fig. 5. Cast Nozzles

For the high-pressure boxes and the diaphragms the packing is made of carbon blocks. For the low-pressure boxes a water impeller is used, so arranged that it does not prevent the adjusting of the clearance between the stationary and revolving elements.

The governor is mounted directly upon the end of the main turbine shaft, as shown in Fig. 3. It is shown more in detail in Fig. 4. The actuating weights consist of the longer arms *a*, of three bell-crank levers fulcrumed upon tool-steel knife-edges, the relative location of which is shown in the detail drawing in the lower right-hand corner, the parts being similarly lettered. The small projections shown at the end of the lever in the section are buffers. As the weights fly outward the member *b*, upon which the other arm of the bell crank presses through tool-steel cup points, is moved to the left against the tension of the spring, turning the larger bell crank *A* around the fulcrum *C* and communicating its movement to the throttle valve through the lever *B*. Additional tension may be put upon the governor through the handwheel *E*, in Fig. 3. The thrust which is interposed between the flyball governor and the valve gear is provided with two ball bearings to take the direct thrust as well as any side thrust due to lack of perfect balance. The usual auxiliary governor, which shuts the turbine down automatically when the speed exceeds a predetermined limit, is included. The bearing lubrication is by the gravity-pressure system with circulating pump, filter and cooler, or by ring oiling with water-cooled bearings.

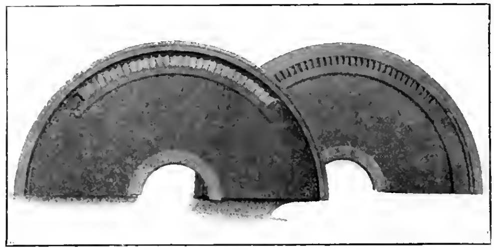


Fig. 6. Cast-In Nozzles

The turbo-alternator, also made by the Ridgway company, is of the revolving-field type, with radial slots for the field coils. In the process of stacking the core numerous air ducts are provided, insuring a more thorough ventilation than is possible with a solid core. Generous ventilating ducts are also provided in the stator, and an outside lagging directs the heated air to an outlet at the bottom. Direct-current turbo-generators are carried directly upon the turbine shaft without the interposition of gearing, the strength necessary to resist the high centrifugal force being secured by holding the winding which is made of bar copper wedged into the slot by heavy bronze rings.

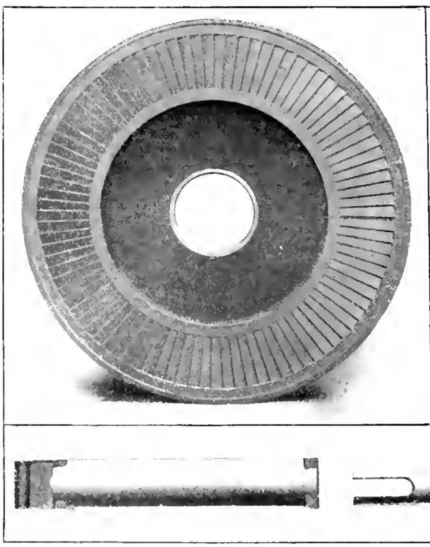


Fig. 7. Full Peripheral Nozzle

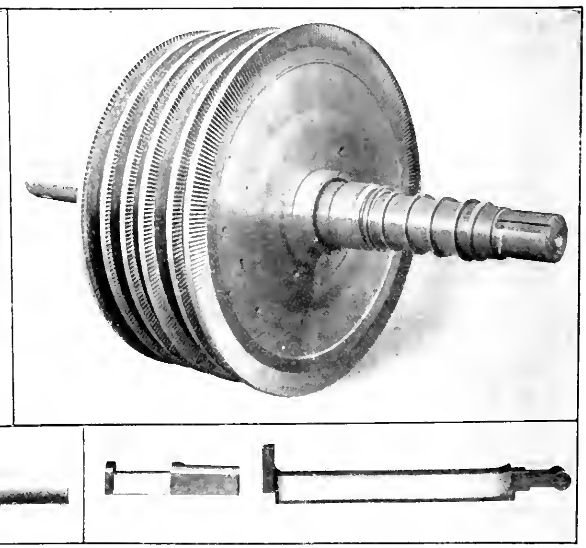


Fig. 8. Full Set of Moving Blades

Simplex Condensation Meter

This meter, Fig. 1, is designed for the measurement of steam used in buildings heated from an outside source, by weighing the water of condensation. It can also be used for measuring various liquids where a gravity discharge permits, but it will not operate under pressure.

The meter consists essentially of a tilting copper bucket which measures the condensation. When sufficient water

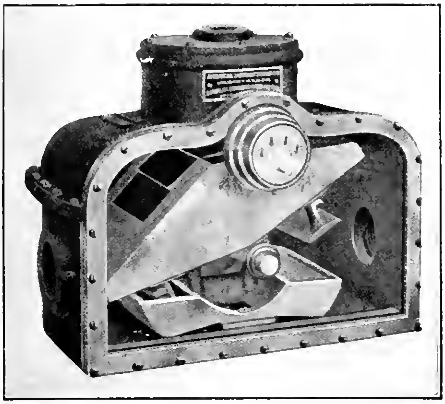


FIG. 1. INTERIOR OF THE SIMPLEX CONDENSATION METER

has run into one side to overbalance it, the bucket tilts, discharging the contents into the meter case, and then through the outlet pipe to the return system or to the sewer. In tilting, the empty side is brought to the filling position. The tilting action is repeated until water ceases to flow to the meter.

The bucket is mounted on a shaft that is supported on roller or ball bearings on the outside of the meter case. In the bottom of the case are dashpots which remain

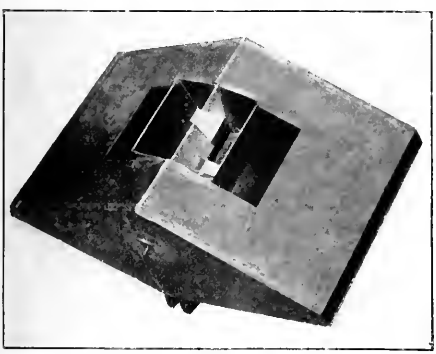


FIG. 2. AUXILIARY BUCKET IN TILTING BUCKET

filled with water and serve as cushions to prevent objectionable noises in the operation. A recording dial indicates the number of pounds of water that have passed through the meter.

To prevent waste of condensation when the tilting occurs, an auxiliary bucket has been arranged to catch the water discharging from the inlet nozzle. This is shown in Figs. 2 and 3. Referring to Fig. 2, the open spaces in the main bucket are for the inlet nozzle to discharge into the empty half. The auxiliary is made with two sections, each discharging to opposite sides of the main tilting bucket, which, when one side contains a certain height of water, starts to tilt to the discharge position.

Fig. 3 shows the operation of the auxiliary in catching the water which would otherwise be wasted between the point of beginning of the bucket dump and the time when the center partition of the main bucket passes under the nozzle. During this period the water is diverted to the empty side.

The auxiliary bucket cannot cut off the total amount of water which would be discharged during the complete tilting movement. It does, however, intercept a large percentage of this waste. Referring to Fig. 3, the heavy arrows marked *A* indicate the bulk of water entering the main bucket. As soon as this has received its full quota of water, it tilts and discharges, and at that instant the edge of the auxiliary bucket passes under the nozzle opening and the water passes into it, as shown by the arrows *B*, thence through a hole in the middle partition to the other side of the bucket, where it is received and weighed on the next discharge. The operation when getting under way for discharging is necessarily slow, and while gather-

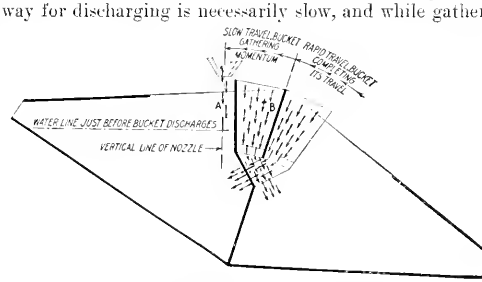


FIG. 3. DIAGRAM OF THE TILTING BUCKET

ing momentum the auxiliary bucket cuts off the water. After the bucket has acquired momentum and is traveling at a rapid velocity, only a small amount is wasted, owing to the fact that it passes over to the other half of the auxiliary and back into the side which has already discharged.

Tests of these meters show that this very simple device, which requires no actuating mechanism, takes up and records the bulk of the waste water which would otherwise have entered the bucket after it had started to dump, and for which, previously, corrections had to be made in the testing.

This meter is manufactured by the American District Steam Co., North Tonawanda, N. Y.

⁂

Steam Separators with receivers of liberal proportions should be used near engines, to provide a reservoir of steam near-by and to minimize pulsations in the lines.

⁂

An Experience in Seeking Help, cited by Charles T. Porter in his "Engineering Reminiscences," is more typical of former times than the present.

"I called upon a friend who was a great mathematician and the editor of a series of mathematical books then largely used, and stated my trouble in calculating the centrifugal force and momentum as applied to my governor. He illuminated the subject to me as follows: 'You seem to be a persevering young man; keep hard at it and you will solve the difficulty by and by.'"

The Uniflow Steam Engine

The fact is established, not only by numerous and repeated tests, but by everyday practice, that the uniflow engine requires only about the same amount of steam as a compound engine. There are others besides our correspondent who cannot see how this can be. Here is one way of accounting for it.

An incredulous correspondent writes:

I studied with interest the article under this heading in Power *of Nov. 17, and as I have written before in regard to this engine, I do not see how it can show good economy.*

Regardless of the test data given (which are undoubtedly correct figures), there remains much that should be explained. Take the figures on page 702 in regard to compression; it is found that with 26-in. vacuum there will be about 38 lb. compression with a clearance of 5 per cent. This does not seem so bad at first thought, but it is bad, for figuring along the same line, I find that at half stroke there is a back pressure of 18 lb.—3.3 lb. above atmosphere. Imagine producing a 26-in. vacuum for an engine that is in direct connection with it for only $\frac{1}{10}$ stroke, and at half stroke is exhausting or, what is of the same effect, has a back pressure over 3 lb. higher than it would have running noncondensing! In the several articles I have seen regarding this engine, the claim is made that the exhaust steam not returning through the cylinder keeps a more even and hotter temperature. So far, in my experience it never has been explained to me why steam is hotter at a given pressure traveling in one direction than in some other. If the engine exhausts down to 2 lb. the temperature will be around 126 degrees, regardless of whether it departs by the back or front entrance. If not, why not? Then again, there is some condensation in any steam cylinder and, as is well known, this portion of the impulse charge sticks more or less to cylinder walls and, in general, lags behind the portion that remains steam. Then it would seem that a large percentage of this near water will not get out of the exhaust, but will remain to be compressed, for that $\frac{9}{10}$ of stroke in the uniflow cylinder. Perhaps this tends to high economy. If so, why?

I note this particular engine has steam jackets. This, of course, will increase the economy of any type of cylinder, but down home it is the custom to take the cost of maintaining this steam jacket. This takes us sort of back to the coal heap, which, after all, is the item that most interests us of the monkey-wrench and overalls. We do not write for argument, we wish to learn. That is why we take Power. *So, if the editor and the higher professors will bear with us and show us just how some nice things are done and why, we will be truly thankful.*

A 100-per cent. engine, i.e., an engine that could turn into work all the heat set free by working steam between 150 lb gage, 100 deg. superheat, and atmospheric pressure, would run on about 13½ lb. of steam per hour per i.hp. The best actual engines require 17 or 18 lb.

If an engine used 18 lb. per hp.-hr., it would develop $^1/_{18}$ of a hp.-hr. per pound of steam. A horsepower-hour is equivalent to 2544.65 B.t.u. Hence, the engine converts

$$2544.65 \div 18 = 141.4$$

of the 1252 B.t.u. which is brought into it with each pound of steam into work.

If the engine had no losses it could run on 13.5 lb. per i.hp.-hr., and convert

$$2544.65 \div 13.5 = 188.5 \text{ B.t.u.}$$

What becomes of the difference between this and the 141.4 B.t.u. converted by the best actual engines and the much less converted by the less efficient types?

The heat which is carried into the engine cylinder by the steam can get out in only three ways:

Radiation;

Conversion to work;

In the exhaust.

And it has got to get out as fast as it goes in, or it will accumulate in the cylinder and melt it down.

The radiation loss from a well lagged cylinder is trifling. It is evident that most of the unutilized heat escapes in the exhaust.

How does it get there?

It is absorbed by the containing surfaces, the cylinder walls, port surfaces, cylinder, and piston heads when the steam is hotter than they are, i.e., through a large part of the forward stroke, and given out to the exhausting steam throughout the entire return stroke, or until, by compression, the temperature of the inclosed steam equals that of the walls.

Whatever goes to nullify or to discourage this transfer of heat between the working medium and the containing surfaces, tends to reduce this bypassing of the heat from the hot to the cold side, from the steam chest to the exhaust, without doing work, and hence tends to increase the efficiency of the engine.

Suppose a cylinder could be so thoroughly jacketed on heads and on barrel with steam so hot that the inside skin of the containing surfaces would be as hot as the entering steam. When the steam came in it would remain in a vaporous or gaseous condition, instead of some 20 per cent. condensing upon the cooler iron, as in the usual case, and it would retain its initial condition until cutoff occurred and expansion commenced. Then it would commence to cool and to absorb heat from the containing surfaces. Perhaps it has some superheat in its initial condition, so that it will not commence to condense immediately, or until the temperature has been reduced by expansion enough to use the superheat all up.

Superheated steam, dry steam, is a very poor absorber of heat. The heat from the cylinder head can radiate or "shine" through it, as the heat from the sun can radiate through the air without warming it up much. It is only when the sun shines on the rocks, and other substances which will readily absorb its heat, and then the air passes over them and picks the heat up by convection, that we get an energetic heating effect. The mere shining of the sun through the air heats it but little, as witness the temperature at elevations where there is little solid material, as compared with the exposure, to absorb and radiate the heat.

Under these conditions it can readily be conceived that even after the expansion has proceeded until the steam is below the saturation point, or even if there is initial condensation, the film in immediate contact with the hot surfaces gets dried out and superheated. Then the absorption of heat from the surfaces stops or becomes very slow.

The effect is analogous to that produced when a stratum of air gets around the cooling surface in a condenser, or when, in a boiler with poor circulation, the steam does not get readily away from the heating surface, or when, in a high vertical radiator, an inside pipe is so smothered that the already heated air hugs it instead of getting away and allowing other and cooler air to come up and be heated. So long, in the case of the engine, as this blanket of highly heated steam can be kept against the hot surfaces, there will be little transfer of heat to the contents of the cylinder, to be carried off in the exhaust.

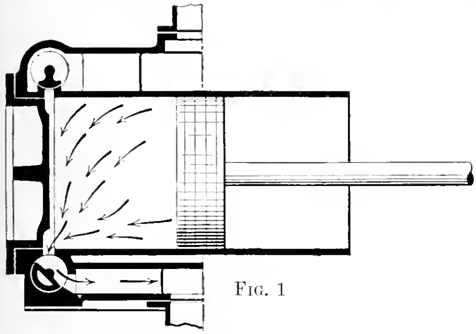


Fig. 1

Now, in the case of the counter-flow, or usual, type of engine, where the exhaust and the steam valves are both at the same end of the stroke, there comes, when the release occurs, an immediate rush of the steam backward toward the hot head, in a struggle to get out at the open exhaust port, as shown in Fig. 1. This steam, even if it were superheated to start with, has become cool and moist by expansion and the conversion, with consequent condensation, of more of its heat into work than it could spare and remain dry. The protecting blanket of superheated steam is swept away from the hot surfaces of the entering end, and the cold wet steam impinging upon these surfaces absorbs heat from them by evaporation and convection to be carried uselessly into the exhaust or to make more work for the condenser. In a single-valve engine, where the same port is used for inlet and exhaust, even the surfaces of the port through which the hot entering steam must come are washed and cooled by this heat-absorbing mixture of low-pressure steam and water.

With the uniflow, or central-exhaust, engine, Fig. 2, there occurs no such reversal of flow. When the piston passes over the central port the steam is released from that end of the cylinder, the hotter steam at the head or jacketed end simply expanding and pushing the cooler wetter steam before it. The protective blanket on the cylinder head and the hot end of the cylinder is not swept off, but remains intact, and all the heat which is carried to the exhaust is that which the steam in the exhaust end of the cylinder can pick up in sweeping over the cooler piston head and the walls near the exhaust port, as it is pushed out of that port by the expansion of the rest of the steam from the pressure at release to that of the exhaust or condenser, and by the backward movement of the piston up to the point where it again covers the central port—usually about one-tenth of the stroke. When the exhaust port is covered there is the volume of the return stroke yet to be completed, plus the clearance volume, full of steam of the exhaust pressure; that near the piston probably at a temperature corresponding to its pressure, that in contact with the hot head superheated considerably above that temperature. As the compression proceeds the temperature rises with the pressure, and there will be some condensation against the piston head, which is now absorbing heat that will be carried off in the next outrush of exhaust, but when the compression stroke is completed the clearance will be full of steam of practically the initial pressure, the cylinder head and clearance surfaces will be good and hot and the piston head as hot as it could get by taking heat from the compressing steam, so that the entering steam is received upon surfaces of about its own temperature and initial condensation much reduced.

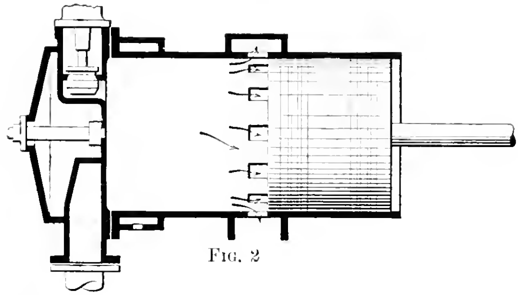


Fig. 2

Our correspondent, in saying that he would not care

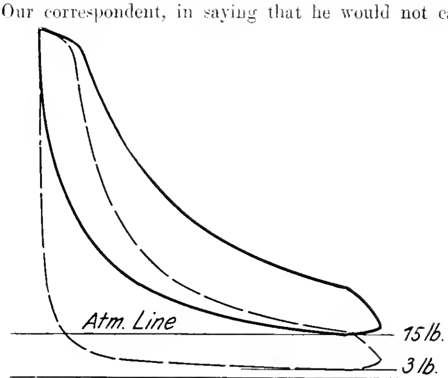


Fig. 3

to maintain a condenser which was in communication with the cylinder for only one-tenth of the stroke, loses sight of the fact that the diminution in the back pressure endures throughout the stroke by reason of the lower initial compression pressure. Fig. 3 will make this plain. The full line represents the counter-pressure running noncondensing, the dotted line condensing, the exhaust port closing when the return stroke is one-tenth completed in both cases. The diagram ought also to make plain to our correspondent that the method by which he computed the absolute back pressure at half stroke to be 18 lb. absolute has something the matter with it. The steam used in the jackets is included in the steam rates reported.

Electric-Motor Noises

By Francis H. Davies

SYNOPSIS—Motor noises classified as to the nature of their causes—namely, magnetic, ventilating, and mechanical. How to detect the cause and the remedy to be applied.

Primarily, the noises arising from the operation of any machine may be divided into two classes—those directly transmitted by the air and those transmitted through the ground and walls. Air-transmitted noises may arise from several causes, but in the case of electric motors they are usually magnetic, being due to vibration of armature teeth and laminated pole shoes under a high-frequency alternating field. Such noises are characterized by a penetrating hum or shriek and are difficult to cure. Their intensity depends upon the field strength, the frequency of reversal, the form of the core and pole stampings, and the manner in which these are put together. Designers appreciate the importance of reducing magnetically generated noises to a minimum, and the following points out what experience has proved necessary to this end.

Magnetic Noises

It is inadvisable that the pitch of the armature slots at the circumference exceed $\frac{5}{8}$ in., as it is found that wide and open slots produce oscillations of the field flux which, acting on the laminations, cause vibration and consequent noise. Where the slots are wide, iron wedges may be inserted, the action of which is to spread out the flux and allow the teeth to enter and leave the field more gradually. The same effect is secured in many armatures by slanting the slots instead of arranging them parallel with the shaft axis; and, with a similar object, pole shoes are sometimes constructed with their horns on the slant as shown in Fig. 1, which allows the core teeth to enter and leave the field gradually. A noisy machine may sometimes be cured by this alteration to the poles, which is comparatively simple provided the poles are of the solid and not the laminated class. It is generally understood that for noiseless running the polar horns should be well rounded and tangential to the armature (Fig. 2) instead of embracing it closely at the tips, the object being to reduce the intensity of the field at the extremities.

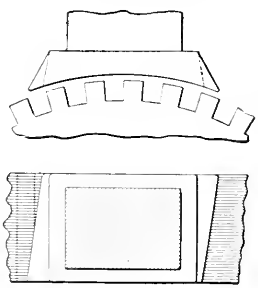


Fig. 1.

Weakening the field by increasing the air gap is another method of minimizing magnetic noise, but this results in a higher speed for an equal output.

Laminated poles are certain to give rise to noise unless the laminæ are so tightly built up that vibration is impossible. Furthermore, the rivets securing the laminations must be as close as possible to the outer edges, particularly those passing through the horns, as this will render them less liable to vibration arising from the rapidly changing density of the magnetic flux as the teeth of the armature core pass the horns. This effect is at a maximum when the number of slots in the armature core is small, because then the magnetic disturbance will be greatest. Therefore, the designer allows for as many slots as possible, taking care also that they are so pitched that one does not leave the pole at the same time as another arrives under it; such spacing will cause maximum swinging of the flux and consequent noise. In other words, the length of the pole face measured on the arc should not be a multiple of the slot pitch.

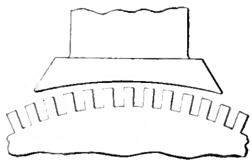


Fig. 2.

Ventilating Noises

Second to magnetically generated noises are those arising from the ventilating arrangements. The churning of the air by revolving parts and its flow at high velocity through the end-shield openings set up a deep noise comparable to that of a fan. It is not very objectionable, but may be lessened by partially closing the vents in the end shields, although this interferes to some extent with the ventilation. It is important that there be as few projecting parts as possible in both the field and armature as these act as vanes and propellers.

A more objectionable noise is that caused by air passing at high speed through ventilating ducts. It is often difficult to distinguish this from magnetic noises. This point may be settled, however, by running the machine up to speed and then switching off the current. It is always possible to modify ventilation noises by reducing the speed, and in some cases a small reduction will be effective.

Mechanical Noises

Noises arising from mechanical causes are usually attributable to faulty design, poor workmanship, or wear. An armature that is out of balance will set up heavy vibrations and an annoying sound that will travel some distance through the framework or walls of the building, unless special steps are taken to isolate the machine. Bearing wear, also, will result in an armature losing its true concentric position with regard to the poles, and this sometimes causes a heavy knock. The remedy for an unbalanced armature is, obviously, to balance it carefully, noting whether it is a case of a sprung shaft and not an original fault, or if the bearings are worn and require replacement. When the bearings are in good condition and it is found that the armature is not truly concentric with the fields owing to bad assembling, this can often be rectified by the insertion of liners or their withdrawal from between the poles and the yoke ring, unless the field be one solid casting. In the latter case liners can sometimes be placed under the bearing pedestals.

Another likely cause of knocking is a loose part, and it is often necessary to overhaul the machine thoroughly in order to locate it. Motors working under arduous conditions of frequent reversal are apt to develop a loose armature core owing to wear of the keyway.

It is well known that sound is carried by solid bodies better than by air; consequently, a noisy motor may cause annoyance at a considerable distance, particularly in the case of buildings of steel structure. In such cases the only remedy is to isolate the machine from the floor, wall or ceiling upon which it is fixed. There are numerous ways of doing this, one particularly good one being the placing of felt under the bedplate, with washers of a similar material inserted under the heads of the holding-down bolts. It is also well to bush the holes in the bedplate with similar felt, for if the bolts touch anywhere they will act as conductors. It should be borne in mind that felt of the ordinary type, such as that used for roofing, is quite useless and cannot long retain any sound- or vibration-absorbing properties that it may originally possess. Special felts are made for this purpose, sometimes with cork and rubber inserts.

Minor Noises

Among the minor noises are those arising from the commutator and brushes. A high bar in the commutator is a not infrequent cause, but the hissing common with many motors is due to the brushes being either too hard, improperly bedded, tight in the boxes, or adjusted at the wrong tension. These faults are easily located and call for only obvious remedies. The motor itself is not always the greatest sinner, and a noisy installation may often be quieted by proper attention to the belting or other form of transmission used. The flapping of a slack belt is easily remedied, though the noise set up by a slipping belt may require more drastic treatment. Should the slip be due to overload a larger belt and, perhaps, larger pulleys must be provided; or if it arises from too small an arc of contact the centers must be increased or an idler pulley employed.

There are also, of course, the usual remedies of wooden or paper pulleys and various dressings having for their object better adhesion of the belt to the pulley. For quiet operation belts should not be run against the joints and metallic fasteners should not be broader than the belt nor project through to the running side. Where chain drives of the "noiseless" type are installed proper attention is all that is required to enable them to justify their name. If, however, they are not properly erected and are allowed to become too worn, dirty and dry, a certain amount of noise is inevitable. Spur gearing is a type of transmission which frequently gives rise to much noise, and for the best results the wheels must be truly cut, well lubricated and correctly distanced. The last is especially important, for if the wheels engage too closely or are too far apart they will cause objectionable noise. Fiber, paper and rawhide pinions are to be recommended and provide the best solution of the problem of quiet spur gearing.

Loop, Ring and Duplicate Steam-Pipe Systems should be indulged in sparingly, especially if much extra length of pipe is involved, or should be so arranged that unused sections can be shut off. This applies, of course, to exaggerated and complicated systems designed to meet every possible contingency. There can be no objection to a complete loop where the boilers and engines are set practically parallel to each other, so that the headers may easily be connected at each end.

JUST FOR FUN

New Commutator Lubricant

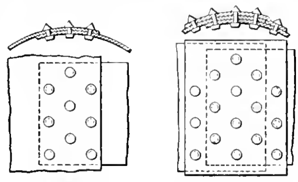
To a young man was assigned the duty of caring for the motor in a small manufacturing concern. It had been the custom to rub the commutator with a cloth dampened with thin oil after the power had been shut off, while the armature was still rotating. One evening the swab cloth was missing, but a bottle of shellac and a cloth were handy, so he used that on the commutator. In the morning the motor refused to start at all, and an inspector was sent for. He found a finely polished commutator, but the brushes were all stuck tight and had to be pried loose.—*R. A. Cultra, Cambridge, Mass.*

A Parallelism Indicator

A glass company in western Pennsylvania had five vertical gas engines of about 600 hp. installed, but brought suit against the builders, claiming that the engines were not as guaranteed. We have one of the same kind, running with the generator in parallel on a 23,000-volt high-tension line. The engine builders and the glass-company officials visited our plant to see the engine and get our reports. After we had explained that the generator was operated in parallel with the main plant about 100 miles away, one of the glass-company officials watched the make-and-break igniters working, and then asked the engineer if the engine was in parallel every time the thing clicked.—*R. G. Curren, Jr., Kittanning, Penn.*

An Improved (?) Boiler Joint

Fig. 1 shows the original longitudinal triple-riveted joint on the shell of a boiler, with an efficiency of 76.5 per cent. The Chief Engineer (?) wanted to have a higher working steam pressure in the plant than he was carrying. He had heard of boiler joints being made stronger by having a cover strap and two additional rows of rivets put in, so he got busy and ordered the change made on his boilers.



Attempt at Strengthening Joint

He cut out all rivets from the original joint and had a cover strap fitted. He had one row of rivets added on each side, as shown, Fig. 2. After all the inconvenience and cost of labor due to this change, he was informed the joint had exactly the same efficiency as before.

The weak point of the original joint was the net section of plate between the outer rows of rivets. In his change he added one row of rivets on each side of the original, but spaced them the same distance apart as the first three rows were. The three center rows were changed from single to double shear, but there still remained the two outer rows in single shear, and the net section between the outer rows had the same value as in the original joint. Therefore the joint efficiency was the same.

If this fellow had asked for proper advice he could have been put right and saved dollars for his company and trouble for himself. The boilers are still in use, but at no higher pressure.—*J. A. Sawyer, Phila., Penn.*

CO_2 and the Character of Fuel

By T. H. Reardon

A high percentage of CO_2 in uptake gases indicates in a general way a high degree of efficiency in the process of combustion, but it may not be so generally known that an increase or decrease in this gas indicates the character of the coal or fuel.

Theoretically perfect combustion is impossible whether conducted with laboratory refinement or with boiler-room methods. By perfect combustion it is understood that the agents that enter into the reaction are present in quantities necessary to yield the final products of combustion with no excess of any reacting element. It is clear that if a sample of pure carbon could be burned to completeness with the theoretically necessary quantity of oxygen, the sole product of combustion would be CO_2 and the percentage of this compound in the combustion products would be 100. Further, if a sample of fuel consisting of both carbon and hydrogen were burned under the same conditions the products of combustion would be CO_2 and water, and if a sample of these products were drawn into an aspirator for subsequent titration with caustic potash it would be found that the water present as aqueous vapor in the condition of superheated steam, would condense, its volume becoming practically nil. This removes it from the sample, leaving only CO_2 as the gas that later will be drawn into the burrette for measurement.

When combustion is supported with the theoretically necessary quantity of air, certain differences will be apparent. Air consists of a mechanical mixture of oxygen and nitrogen, the proportions by volume being usually taken as, oxygen, 21 per cent.; nitrogen, 79 per cent. If the complete combustion of carbon could be carried out with the theoretically necessary quantity of air, the percentage of CO_2 in the stack gases would be the same as that of oxygen in the air, viz., 21 per cent. This is a limiting high mark obtainable only with ideal conditions and with a combustible consisting entirely of carbon.

As soon as experiments are made with a fuel consisting of a mixture of carbon and hydrogen, the percentage of CO_2 in the products of combustion will diminish, even with perfection in the processes.

Carbon unites with oxygen according to the equation

$$C + O_2 = CO_2;\ 12 + 32 = 44.$$

Hydrogen unites in a similar way with oxygen as follows:

$$2\ H_2 + O_2 = 2\ H_2O;\ 4 + 32 = 36.$$

An inspection of the equations shows that 12 parts by weight of carbon require 32 parts by weight of oxygen for perfect combustion, or 1 part by weight of carbon requires $2\frac{2}{3}$ parts of oxygen. For hydrogen we find that 2 parts by weight require 16 parts by weight of oxygen, or 1 part hydrogen requires 8 parts of oxygen. The weights and volumes of air required for carbon consumption and for hydrogen, respectively, are in the same proportion, i.e., weights being equal, hydrogen requires three times as much oxygen or air for its combustion as carbon does.

Each per cent. of hydrogen content in the fuel, therefore, reduces the percentage of CO_2 0.21 per cent., because in combustion hydrogen yields no CO_2 and dilutes the stack gases by introducing three times as much inert nitrogen as would accompany the oxygen used in case the hydrogen content of the fuel had been carbon.

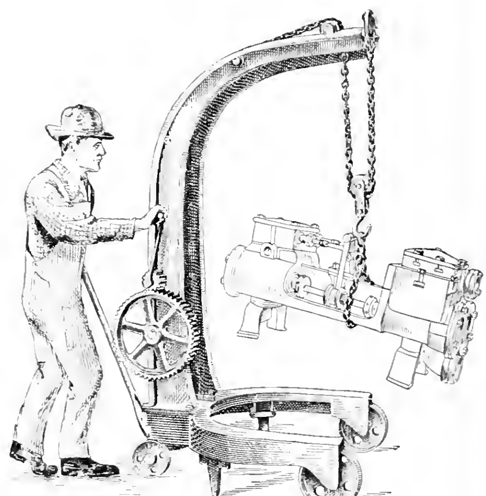
It is obvious that as hydrogen increases in amount in the fuel the percentage of CO_2 must diminish, and that if the hydrogen became equal to 100 per cent., the percentage of CO_2 would be 0.

A study of this subject is interesting, and will materially aid in making clear the significance of CO_2 in the stack gases and the extent to which its presence is influenced by various factors.

Canton Portable Floor Crane and Hoist

Engineers will find the Canton portable floor crane and hoist a convenient, and in some plants a necessary appliance for handling heavy work which would require several men and much time to perform by hand.

The crane bed is fitted with two rear-bearing and two



Portable Floor Crane and Hoist

guide wheels. The latter are provided with a tongue so that the tool can be pulled from one part of the plant to another, the same as if the load were on an ordinary truck. The crane arm and its windlass are bolted to the body.

In the engine room the contrivance will be found convenient for handling cylinder heads, heavy pillar-block caps, steam pumps or any other apparatus which would require jacking, especially where an overhead crane is not available.

This hoist is manufactured by the Canton Foundry & Machine Co., Canton, Ohio.

A Fine Engine-Room Performance—The sinking of the German cruiser "Nürnberg" by the British cruiser "Kent," in the action off the Falkland Islands, was due, primarily, to the remarkable work done by the engine-room and stokehole staffs of the "Kent." The trial speed of the "Kent," which was an eleven-year-old ship, was 22½ knots, and it looked as though her attempt to overtake the 23½-knot "Nürnberg" would be fruitless. But in response to the captain's appeal, the engineering force managed to push the speed up to 24 knots per hour, or one knot more than the ship had ever steamed since she first went into commission, and gradually she overhauled and got within range of the enemy.—"Scientific American."

A Brief History of the Thermometer

By W. S. Atchison

In looking at a thermometer—apparently a glass tube containing either quicksilver or a colored liquid and having some sort of a scale—one is not apt to realize the thought, skill and research it has taken to bring this simple, yet universally necessary article to its present state. For many centuries scientists have worked in an endeavor to perfect it, but only during the past forty years have they found out all the details necessary to the manufacture of a more or less perfect article.

Many people are credited with the invention of the thermometer, Drebble, a Hollander, being referred to more than any other; but to Galileo Galilei the laurels should probably be handed. According to history it seems that about 1592 he invented at Padua an instrument described as "a glass containing air and water, to indicate changes and differences in temperature."

With the idea started, the Grand Duke of Tuscany investigated this invention and improved it more or less between 1630 and 1640. The original thermometer consisted of a glass tube about 16 inches long with a hollow ball, or bulb, at the end. The whole was heated until the air inside became rarefied, when the open end was placed in water, the tube being kept upright. As the air in the tube cooled or contracted, the fluid (water was originally used) rose to a certain point and any subsequent changes caused the level of the fluid to be either elevated or depressed.

This was used by Sanctorius as a "heat measure," or fever thermometer. It is on record that he had his patients hold the top of the thermometer so the level of the fluid would be arrested at a point equal to the temperature of the person holding it. A point was undoubtedly determined by a normal, healthy person beforehand, and it is reasonable to assume that Sanctorius drew his deductions by noting the distance above or below this "normally healthy" person.

Before ten years had passed the Grand Duke of Tuscany had carried out his idea of first partly filling the tube with alcohol and closing the open end, thus sealing it and excluding the air. Realizing that the level of the liquids in these various instruments meant nothing, pupils of Galileo sought to make a scale of temperature and melted onto the tube of their thermometers small glass balls about the size of a pin's head, the zero of the scale being the point to which the liquid fell in a freezing mixture of salt and water.

At one time the bright minds of Europe decided that the freezing point of liquids varied to such an extent that it could not be used as a test point, and suggested taking the temperature in a cave cut straight into the bottom of a cliff fronting the sea to the depth of 130 ft., with 80 ft. of earth about it.

About 1662 Hooke, placing his instrument in freezing distilled water, marked "zero" at the top of the column of spirit after immersion of the bulb. Soon after this he suggested that the second point should be the boiling point of water, but this was not adopted at the time. Delance suggested that the freezing point of water should be marked "cold" (—10 deg.) the melting point of butter "hot" (+10 deg.) and the space midway between "temperate" (0 deg.), with ten divisions between each.

In 1714 Fahrenheit arranged a scale for thermometers that showed the freezing of water at 32 deg. and the boiling of water at 212 deg. Many suggestions have been made as to why he graduated the freezing and boiling of water into 180 divisions, one being that as he was an astronomical-instrument maker and as his machines divided to full circles (360 divisions), he used a half-circle for his scale. Seventeen years later Réaumur, a French physicist, brought out a scale on which the freezing point of water appeared as 0 deg., the distance between this and the boiling point of water being divided into eighty equal parts. Anders Celsius, professor of astronomy at the University of Upsala, proposed a scale in 1742 and called the freezing point of water 100 deg. and the boiling point of water zero degrees.

These points were afterward reversed by Christin of Lyons (France) in 1843, and the result is the well-known Centigrade scale. Athanasius Kircher was the first to use quicksilver in thermometers. Quicksilver and alcohol have been accepted by the scientific world as convenient and accurate means to indicate the temperature of anything with which the tube containing them may come in contact.

For high temperatures quicksilver is used, as it freezes at about —38 deg. F. (—39 deg. C.) and boils at 662 deg. F. (+357 deg. C.). As the freezing point of mercury is fairly high, alcohol thermometers are invariably used in very cold climates. This liquid freezes at —203 deg. F. (—130.5 deg. C.) and boils at 173.5 deg. F. (+78.5 deg. C.).

From the foregoing it will be seen that quicksilver is unsuitable for any very low temperature and alcohol is unsuitable for any very high temperature.

Conversion of Thermometer Scales

To convert Centigrade degrees to Fahrenheit degrees, multiply by 9, divide the product by 5 and add 32, if the temperature is above 0 deg C. When the temperature is below 0 deg. deduct 32 instead of adding.

In converting Fahrenheit degrees to Centigrade degrees subtract 32, multiply by 5, and divide by 9, if the temperature is above 0 deg. F. When the temperature is below 0 deg. F. add 32 instead of subtracting.

To convert Réaumur degrees to Fahrenheit degrees multiply by 9, divide by 4 and add 32, if the temperature is above 0 deg. R. When the temperature is below 0 deg. deduct 32 instead of adding.

In converting Réaumur degrees to Centigrade degrees, multiply by 5 and divide by 4.

To convert Centigrade degrees to Réaumur degrees, multiply by 4 and divide by 5.

Centigrade, water freezes at 0 deg. and boils at 100 deg.

Fahrenheit, water freezes at 32 deg. and boils at 212 deg.

Réaumur, water freezes at 0 deg. and boils at 80 deg.

Uses of Tungsten—Tungsten is used principally as an alloy of high-speed steel—that is, steel used in making tools used in metal-turning lathes running at high speed—to which it imparts the property of holding temper at higher temperature than carbon steels will, according to the U. S. Geological Survey. The now well known ductile tungsten is used for incandescent lamps, which are fast displacing carbon lamps. This alloy is practically insoluble in all the common acids, its melting point is higher than that of any other metal, its tensile strength exceeds that of iron and nickel, it is paramagnetic, it can be drawn to smaller sizes than any other metal (0.0002 in. in diameter), and its specific gravity is 70 per cent. higher than that of lead.

Power Plant of the Government Printing Office

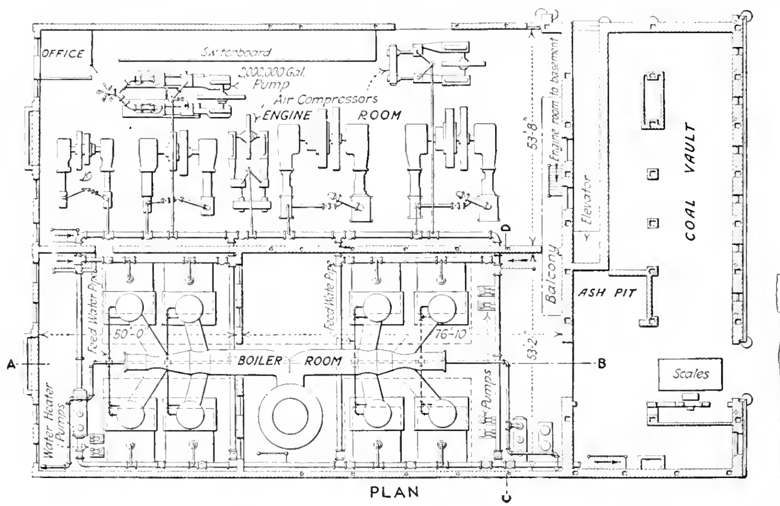
By Davis H. Tuck

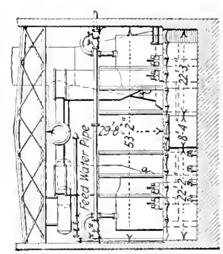
SYNOPSIS—Wherein one plant supplies light, heat and power for the Government printing office and for the new Washington post office. The old plant was remodeled and the electrical circuits changed from a two-wire, 120-volt to a three-wire, 240-120-volt system. Test figures of the redesigned plant are given.

Due to the proximity of the new Washington, D. C., post office to the Government printing office it was deemed advisable to obtain energy for heat, light and power from the power plant of the printing office. The electrical energy required by the printing office had increased until the distributing lines were likely to become overtaxed with a subsequent increase of load. The generating equipment had been added to from time to time until there were four units in the plant. The power-receiving circuits of the new post office were designed for 240, and the lighting system for 120 volts. The power-receiving circuits of the printing office were for 120 volts.

After an analysis of these conditions it was decided to change the two-wire, 120-volt system, to a three-wire, 240-120-volt system to meet the requirements of the new post office and at the same time increase the capacity of the distributing circuits of the printing office. It was also decided to replace one of the small reciprocating generating units by a turbo-generator of sufficient capacity to carry the load of both the printing office and the new post office. By such a change a gain in efficiency could be realized by the substitution of a more efficient prime mover and by the utilization of one unit of relatively large capacity in place of several small units.

The boilers in the plant were overtaxed during the winter months by the requirements of the printing office and were not adequate for the increased load imposed by the new post office. Therefore, it was necessary to add to the boiler equipment and, as the stack was not large enough to produce the additional draft required by the additional boilers, it was necessary to build a suitable stack.





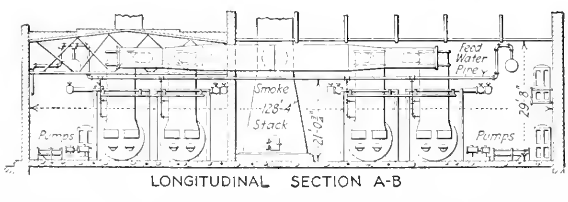


Fig. 1. Plan and Elevation of the Plant before the Change Was Made

Fig. 1 is a plan and elevation of the plant before the changes were made. The boiler equipment consisted of eight 300-hp. hand-fired Scotch-marine boilers with auxiliary apparatus including two feed-water heaters. The generating equipment consisted of two cross-compound Allis engines directly connected to two 500-kw. Crocker-Wheeler direct-current generators, one similar unit of 300-kw. capacity, and another of 125-kw. capacity. Two air compressors of 1500 cu.ft. of free air per minute capacity supply air at 50 lb. pressure to various industrial processes in the printing office. One pump of 2,000,000 gal. per 24 hr. capacity maintains a high-pressure system for industrial processes and for fire protection in both buildings.

The original plans of the changes to be made include the installing of four 500-hp. water-tube boilers with superheaters, stokers, feed pumps and piping; an alternative plan called for putting in two boilers with auxiliaries, similar to those already in place, should the appropriation not permit of water-tube boilers.

The new feed-water heater was to have a capacity for heating the water for not less than 1600 hp. of boilers to a temperature within 2 deg. of that of the exhaust steam. All piping in that part of the boiler house which was to contain the new boilers, except the main steam header, was to be removed, and all steam, exhaust, water and waste piping necessary for the new equipment put in. Changes in the heating feed pipes in the printing office and for the post office were also to be made, and coal- and ash-handling machinery was to be put in for both the new and the old boilers. The erection of a 200-ft. chimney to be 10 ft. 6 in. inside diameter at the top to serve the new boiler was also contemplated.

The new turbine and three-wire generator were to be of 1000-kw. capacity. In the proposal for this unit it was stated that in case the guarantees of the builders

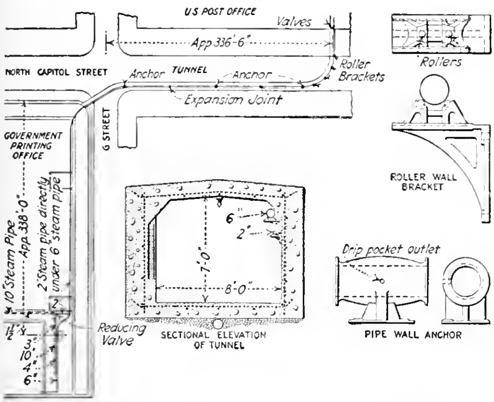


Fig. 2. Details of Tunnel Construction and Wall Brackets

differed, they would be evaluated for the purpose of comparison as follows: The cost to generate steam to be taken at 16c. per 1000 lb., the unit being assumed to operate 16 hr. per day, 365 days in the year, and the algebraic sum of the savings at one-half, three-quarter, full and one and one-half load, with load factors of 20, 50, 15 and 5 respectively, would represent the gross savings per year effected by the units with the lower steam consumption over the unit with higher.

The generator was to have a capacity for two hours of 150 per cent. of its normal load of 1000 kw. The maximum temperature rise of the generator, after being run at full normal load continuously for 24 hr., was not to exceed by more than 45 deg. C. the temperature of the surrounding air corrected to a standard room temperature of 25 deg. C., in accordance with the standards adopted by the American Institute of Electrical Engineers.

Changing of the 300-kw., 120-volt generator to a three-wire 120-240-volt generator and all necessary connections and wiring to the switchboard were also included in the original plans, also the changing of the switchboard and instruments from the two-wire to a three-wire system. The two 600-kw. generators were to be connected in series to form a three-wire system. There would then be installed one unit of 300-kw., one of 1000-kw. and one of 1200-kw. capacity. The switchboard was to consist of 16 panels and two sets of busbars, one for lighting and one for power, with switches so arranged that either set of busbars could be used for either lighting or power.

A tunnel from the printing office to the post office for the steam piping for heating and for the electric wiring was required, the construction of which was to conform with the plan and elevation in Fig. 2. A wall bracket, anchor and roll supports such as used are also shown. The tunnel is of course larger than necessary for this particular purpose, but was made large enough to accommodate a future mail-conveying equipment.

As the appropriation made by Congress for the additions to the power plant was not sufficient to carry out all of the improvements planned, it was decided to distribute the appropriation and purchase two 500-hp. water-tube boilers, without superheaters, one feed-water heater, all necessary piping, ash-handling machinery, chimney, turbine and generator to carry out the changes on the 300-kw. generator and switchboard and to construct the tunnel.

It was also decided to change the two 600-kw. 120-volt generators to 240-volt generators and install balancer sets for the new three-wire system instead of cross-connecting them as originally intended. The new plant therefore consists of one 300-kw. generator, two 600-kw. generators and one 1000-kw. generator all arranged for the three-wire system.

Referring to Fig. 1, the two 300-hp. Scotch marine boilers at the right of the new chimney were replaced by two 500-hp. Babcock & Wilcox, cross-drum, water-tube boilers. The old stack, which was of steel construction lined with firebrick, 6 ft. 4 in. inside diameter and 150 ft. high, was removed and the new 200-ft. brick stack was constructed as indicated. The 125-kw. unit next to the office was replaced by the 1000-kw. turbo-generator, which upon acceptance tests conformed to the guarantees of the makers. The results of the tests of the boilers and turbo-generators are given in detail in the accompanying reports.

On account of the amount of steam used for other purposes, including steam heat, live steam for industrial uses, for pumping water and for use in air compressors, a test was made on the steam-generating engines and it was found that they used about 20.5 lb. of water per kilowatt-hour. Then the total coal consumed multiplied by 20.5 and divided by the total water evaporated gives the coal consumed per kilowatt-hour. From this point the following formula is used to determine the cost of energy per kilowatt-hour.

$$\text{Cost per kw.-hr.} = \frac{\dfrac{w \times kw.\text{-}hr. \times c}{W} \times (Be\ Ew)\left(Ee\ De\ Ew\dfrac{o}{2}\right)}{kw.\text{-}hr.}$$

where

W = Total pounds of water evaporated;
w = Water evaporated per pound of coal;
Be = Boiler-room expense;
De = Dynamo expense;
c = Coal per kilowatt-hour;
Ew = Engineer's wages;
Ee = Engine-room expense (engines and generators only);
o = Office expense.

The load factor, defined as the ratio of the average load

Test No. 1—Report of Steaming Test of Fuel

Results of boiler trial made by the U. S. Bureau of Mines at the Government printing office, Washington, D. C., to determine the ability to make the guarantee at 150 per cent. rating.

Principal conditions governing trial: **Draft kept about constant**; coal wet in hopper.

Dimensions, Proportions, Etc.

Boiler, Babcock & Wilcox Cross Drum	
Grate surface, sq.ft	102
Water-heating surface, sq ft	5200
Date of trial	Sept. 22-23, 1914
Duration of trial, hr. (9:00 p m. to 3:00 p.m.)	18 00
Method of starting and stopping test	Alternate
Kind of coal	New River

Average Pressures, Temperatures Fahrenheit, Etc.

Steam pressure by gage, lb. per sq in.	129 3
Force of draft between damper and boiler, in. of water	0 72
Force of draft in furnace, in. of water	0 59
Temperature of air entering ashpit, deg.	94
Temperature of feed water entering boiler, deg.	72
Temperature of escaping gases from boiler, deg.	540

Quality of Steam

Per cent. of moisture in steam	0 0
Quality factor of steam (dry steam = unity)	1 000

Total Quantities

Weight of coal as fired, lb.	47,595
Per cent. of moisture in coal	3 09
Total weight of dry coal consumed, lb.	46,032
Total dry ash and refuse, lb	4,415
Total combustible consumed, lb.	41,617
Total combustible consumed, determined from analysis of coal and refuse, lb.	41,440
Ratio of dry ash and refuse to dry coal, per cent	9 6
Total weight of water fed to boiler, lb.	426,438
Equivalent water fed to boiler from and at 212 deg., lb	506,608
Total water evaporated, corrected for quality of steam, lb	426,438
Factor of evaporation based on temperature of water entering boiler	1 188
Total equivalent evaporation from and at 212 deg F., lb.	506,608

Hourly Quantities and Rates

Dry coal charged per hr., lb	2,557
Coal as fired, charged per hr, lb.	2,639
Combustible consumed per hr., lb	2,312
Combustible consumed per hr., determined from an analysis of coal and refuse, lb.	2,302
Dry coal charged per sq.ft. of grate surface per hr, lb	25 07
Combustible consumed per sq.ft. of water heating surface per hr., lb.	0 445
Water evaporated per hr., corrected for quality of steam, lb.	23,691
Equivalent evaporation per hr., from and at 212 deg F., lb	28,145
Equivalent evaporation per hr from and at 212 deg F. per sq.ft. of water heating surface, lb.	5.412

Approximate Analysis of Coal, Test Sample

	Per Cent.	As Fired, Per Cent	Laboratory Moisture and Ash Free Per Cent.
Moisture	3 1	3 09	
Volatile matter	20 7	20 56	22 45
Fixed carbon	70 9	71 06	77.55
Ash	5 3	5 29	
Total	100 00	100 00	100 0
Sulphur (separately determined)		1 10	1.20
Moisture as fired, as per cent. of moisture and ash free coal, test sample		3 38	

Ultimate Analysis of Coal, Car Sample

	Moisture Free Per Cent.	Moisture and Ash Free Per Cent.
Hydrogen	1 5	4 77
Carbon	83 8	88 65
Nitrogen	1 6	1 72
Oxygen	3 5	3 66
Sulphur	1 1	1.20
Ash	5 5	.....
Total	100 00	100.00

Analysis of Refuse, Moisture Free

	Per Cent.
Combustible	47 0
Earthy matter	53 0
Total	100.00

Calorific Value

Calorific value by oxygen calorimeter, per lb. of dry coal, B t.u.	14,727*	14,722
Calorific value by oxygen calorimeter, per lb. of combustible, B t.u.	15,584*	15,574
Calorific value by oxygen calorimeter per lb. of coal as fired, B t.u	14,270*	14,267

*Used in computation; other determinations made as check.

Capacity

Evaporation per hr. from and at 212 deg. F., lb.	28,145
Hp. developed (34.5 lb. of water evaporated per hr. into dry steam from and at 212 deg. F. equals one hp.) B.hp.	815 8
Rated capacity per hr., from and at 212 deg. F., lb.	17,940
Percentage of builders rated hp. developed, per cent.	156 9

Economy Results

Water fed per lb. of coal as fired, lb.	8 98
Water evaporated per lb. of dry coal, lb.	9 26
Equivalent evaporation from and at 212 deg. F. per lb. of coal as fired, lb.	10 66
Equivalent evaporation from and at 212 deg. F. per lb. of dry coal, lb.	11.1
Equivalent evaporation from and at 212 deg. F. per lb. of combustible, lb.	12.17
Equivalent evaporation from and at 212 deg. F. per lb. of coal as determined from analysis of coal and refuse	12.23

Efficiency

Efficiency of boiler including grate, heat absorbed by boiler per lb. of dry coal, divided by heat of one lb. of dry coal, per cent.	72.5
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, divided by heat value of one lb. of combustible per cent.	75.8
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, determined from analysis of coal and refuse divided by heat value of one lb. of combustible, per cent.	76.2

Smoke Data

Percentage of smoke as observed, Ringelmann chart method per cent. black	0.0

Methods of Firing

Average thickness of fire, in.	7
Air per lb. of dry coal, lb.	16.6
Air per lb. of combustible, lb.	17.6

Analysis of Dry Gases by Volume

Carbon dioxide (CO_2), per cent	12 2
Oxygen (O_2) per cent.	7.1
Carbon monoxide (CO), per cent	0 1
Nitrogen (N_2), Argon (A_2), and inert gases, by difference, per cent.	80.6
Total	100 00

Heat Value or the Distribution of the Heating Value of the Combustible

	Combustible Burned B.t.u.	Per Cent.
Heat absorbed by boiler	11,868	76.1
Loss due to evaporation in coal	42	0.3
Loss due to heat carried away by steam formed by burning hydrogen	535	3.4
Loss due to heat carried away in dry flue gases	1,944	12.5
Loss due to carbon monoxide	73	0 5
Loss due to combustible in ash and refuse	731	4.7
Loss due to heating moisture in air	......	....
Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for	391	2.5
Total calorific value of one lb. of combustible	15,584	100.00

Test No. 2—Results of Boiler Trial at 50 per Cent. of Rating

Made by U. S. Bureau of Mines at the Government printing office, Washington, D. C., to determine the ability to make guarantee at 50 per cent. of rating.

Principal conditions governing trial: Coal wet in hopper throughout test; load steady.

Dimensions, Proportions, Etc.

Boiler, Babcock & Wilcox Cross Drum	
Grate surface, sq.ft chain grate	102
Water heating surface, sq ft.	5200
Date of trial	Sept 21-22, 1914
Duration of trial, hr. (9:02 a m to 3:02 a m)	18
Method of starting and stopping the test	Alternate
Kind of coal	New River
Size of coal, run of mine	Apparently

Average Pressures, Temperature Fahrenheit, Etc.

Steam pressure by gage, lb. per sq in	129 4
Force of draft between damper and boiler, in. of water.	0 11
Temperature of air entering ashpit, deg	98
Temperature of feed water entering boiler, deg	71
Temperature of escaping gases from boiler, deg.	360

Quality of Steam

Per cent. of moisture in steam.	0 2
Quality factor of steam (dry steam = unity)	0 998

Total Quantities

Weight of coal as fired, lb	22,890
Per cent of moisture in coal	2.71
Total weight of dry coal consumed, lb.	22,272
Total dry ash and refuse, lb	2,545
Total combustible consumed, lb.	19,727
Total combustible consumed determined from analysis of coal and refuse, lb.	19,771
Ratio of dry ash and refuse to dry coal, per cent.	11.4
Total weight of water fed to boiler, lb.	215,172
Equivalent water fed to boiler from and at 212 deg. F., lb.	255,840
Total water evaporated corrected for quality of steam, lb	214,742
Factor of evaporation based on temperature of water entering boiler.	1 189
Total equivalent evaporation from and at 212 deg F., lb.	255,328

Hourly Quantities and Rates

Dry coal charged per hr., lb.	1237
Coal as fired, charged per hr, lb.	1272
Combustible consumed per hr., lb.	1096
Combustible consumed per hr., determined from an analysis of coal and refuse, lb.	1096
Dry coal charged per sq ft. grate surface per hour, lb.	12 13
Combustible consumed per sq ft. of heating surface per hr., lb.	0 211
Water evaporated per hour, corrected for quality of steam, lb.	11,930

Test No. 2—*Continued*

Approximate Analysis of Coal. Test Sample

	Per Cent.	As Fired, Per Cent.	Moisture and Ash Free Per Cent.
Moisture	2 7*	2 71	
Volatile matter	21 5*	21.35	23 29
Fixed carbon	70 2*	70 30	76 71
Ash	5 6*	5.64	
Total	100 00	100.00	100 00
Sulphur separately determined		1.13	1 23
Moisture as fired, as per cent of moisture and ash free coal, test sample		2.94	

Ultimate Analysis of Coal. Car Sample

	Moisture Free Per Cent.	Moisture and Ash Free Per Cent.
Hydrogen	4 4	4 71
Carbon	84 6	89 80
Nitrogen	1 6	1.74
Oxygen	2 4	2.52
Sulphur	1 2	1.23
Ash	5 8	
Total	100.00	100.00

Analysis of Refuse, Moisture Free

	Per Cent.
Combustible	47 9
Earthy matter	52 1
Total	100.00

Calorific Value

Calorific value by oxygen calorimeter, per lb. of dry coal, B.t.u.	14,666*	14,706
Calorific value by oxygen calorimeter, per lb. of combustible, B.t.u.	15,569*	15,611
Calorific value by oxygen calorimeter, per lb. of coal as fired, B.t.u.	14,270*	14,308

Capacity

Evaporation per hr. from and at 212 deg. F., lb.	14,185
Hp. developed (34.5 lb. of water evaporated per hr. into dry steam from and at 212 deg. F. equals one boiler hp)	411 2
Rated capacity per hr., from and at 212 deg. F., lb.	17,940
Builder's rated boiler hp.	520
Percentage of builders' rated hp. developed, per cent	79.1

Economy Results

Water fed per lb. of coal as fired, lb	9.40
Water evaporated per lb. of dry coal, lb.	9 64
Equivalent evaporation from and at 212 deg per lb. of coal as fired, lb.	11 15
Equivalent evaporation per lb. of dry coal, lb	11 46
Equivalent evaporation per lb of combustible	12 49
Equivalent evaporation from and at 212 deg F per lb. of combustible determined from an analysis of coal and refuse, lb.	12 91

Efficiency

Efficiency of boiler, including grate heat absorbed by boiler per lb. of dry coal, divided by heat value of one lb. of combustible	75 8
Efficiency of boiler, heat absorbed by boiler per lb. of combustible, divided by heat value of one lb. of combustible	80 7
Efficiency of boiler, heat absorbed by boiler per lb of combustible, determined from analysis of co l and refuse, divided by heat value of one lb. of combustible	80 5

Smoke Data

Percentage of smoke, as observed, Ringlemann chart method, per cent. black	0 0

Methods of Firing

Average thickness of fire, in.	5.5
Appearance and action of coal on grate; burns well when wet.	
Description of flame, difficulties in handling fire, refuse, clinker, and general remarks Short yellowish flame; refuse high in carbon.	
Air per lb. of dry coal	14.4
Air per lb. of combustible	15.3

Analysis of Dry Gases by Volume

	Per Cent.
Carbon dioxide (CO_2)	14 3
Oxygen (O_2)	4.6
Hydrogen, and hydrocarbons	0.1
Nitrogen (N_2), Argon (A_2), and inert gases (by difference)	81 0
Total	100 00

Heat Balance or Distribution of the Heating Value of the Combustible

	Combustible Burned B.t.u.	Per Cent.
Heat absorbed by boiler	12,528	80.5
Loss due to evaporation of moisture in coal	34	0 2
Loss due to heat carried away by steam formed by burning hydrogen	490	3.1
Loss due to heat carried away in dry flue gas	996	6 [illegible]
Loss due to carbon monoxide	63	0.4
Loss due to combustible in ash and refuse	900	5.8
Loss due to heating moisture in air	......	......
Loss due to unconsumed hydrogen and hydrocarbons, to radiation, and unaccounted for	558	3.6
Total calorific value of one lb. of combustible	15,569	100.00

Shop and Acceptance Tests of Turbine

Shop Test

Test Number	19	20	21
Date	3-5-14	3-5-14	3-6-14
Time, from	4:30	7:30	3:05
Time, to	5:30 p.m.	8:30 p.m.	4:05 a.m.
Per cent. of normal full load	50	100	150
Throttle pressure, lb. per sq.in., gage	149 5	150.3	151.5
Inlet pressure, lb. per sq.in., gage	65 2	125 8	137.4
Vacuum in l.p. outlet by mercury column	26 64	26 3	25.5
Vacuum referred to 30-in. barometer	27 53	27 22	26.46
Barometer	29 11	29 08	29.04
Temperature at throttle inlet, deg. F.	374.5	375.7	375.5
Speed shown by continuous counter indicator, r p m.	3642	3609	3583
Load in kilowatts	500	1000	1500
Total net lb. of steam condensed per hr.	10,862	19,161	31,329
Lb. of steam per kw.-hr.	21 72	19.16	20.9
Superheat at throttle, deg. F.	9	9.8	9

Acceptance Test

Vacuum, full load, in. of mercury	27
Vacuum, 150 per cent. of full load, in. of mercury	26 5
Temperature of injection water, deg. F.	80
Temperature of discharge water full load, deg. F	86
With 125 per cent. full load, deg. F.	92
Injection water used, lb. per hour	1,399,360
Steam pressure, lb. per sq.in.	130

Power Plant—Statement of Operating Expenses

September, 1914

Operation:	Total	Cost per Kw.-hr.	Remarks
Boiler-room labor	$519.67	0 164c.	
Engine-room labor	577 83	0.182	
Dynamo-room labor	445 50	0.140	
Fuel	1,530.03	0 482	
Water	....	.....	
Engine oil	....	.....	
Cylinder oil	51 62	0 016	
Waste	2 73	0 001	
Boiler-room supplies	79 24	0 025	Excl. of coal
Engine-room supplies	13 27	0.004	Excl. of waste and oil
Dynamo-room supplies	...	....	
Office force and supplies	101 01	0 032	
Ash handling	19 78	0 006	
Total	$3,340 68	1.052c.	
Maintenance and Repairs:			
Buildings and fixtures	$22 98	0 007c.	
Boilers	53.62	0 017	
Economizers	....	...	
Pumps	4.76	0 002	
Auxiliaries, boiler room	14 66	0 005	
Piping	28 76	0.009	
Engines	1.00	.....	
Generators	....	.....	
Condensers	....	.....	
Switchboard and meters	......	.....	
Auxiliaries, engine-room	4.08	0 001	
Total	$129 86	0 041c.	
Total—power plant	$3,470 54	1 093c.	

Total output, kw-hr., printing office	280,316.1
Total output, kw.-hr., post office	36,792.9
Total kw.-hr., including both	317,109 0
*Total coal consumed (854 tons 289 lb.)	1,913,249.0 lb.
Total lb. water evaporated	15,846,713.0 lb.
Average lb. water per lb. coal	8.28 lb.
Coal consumed for electrical purposes (350 tons 432 lb)	784,432.00 lb.

*For all purposes.

October, 1914

Operation:	Total	Cost per Kw.-hr.	Remarks
Boiler-room labor	$601 29	0 152c.	
Engine-room labor	618 34	0 156	
Dynamo-room labor	465 85	0 118	
Fuel	1,889 93	0 477	
Water	....	..	
Engine oil	35.28	0.009	
Cylinder oil	....	.....	
Waste	1 53	...	
Boiler-room supplies	16 91	0 004	Excl. of coal
Engine-room supplies	21 22	0 005	Excl. of waste and oil
Dynamo-room supplies	1 30		
Office force and supplies	80 41	0 020	
Ash handling	17 37	0 004	
Total	$3,749 43	0 945c.	
Maintenance and Repairs:			
Buildings and fixtures	$21 62	0 005c.	
Boilers	16 84	0 004	
Economizers	..	.	
Pumps	7 76	0 002	
Auxiliaries, boiler room	33 74	0 009	
Piping	26 12	0 006	
Engines	14 70	0 004	
Generators	....	.....	
Condensers	....	.....	
Switchboard and meters		...	
Auxiliaries, engine-room	1 87	..	
Total	$122 65	0 030c.	
Total—power plant	$3,872 08	0 975c.	

Total output, kw-hr, printing plant	332 521.2
Total output, kw.-hr., post office	6[illegible].400.5
Total output, kw-hr, both	39[illegible],921 7
*Total coal consumed (tons 1220+2225 lb)	2,735,025 0 lb.
Total lb. water evaporated	22,288 332 0
Average lb. water evaporated per lb. coal	8 13
Coal consumed for electrical purposes (tons 439+1249 lb).	984,609 lb.

*For all purposes.

for the twenty-four hours to the maximum load for that time, is about 71.7 per cent.

The cost per kilowatt-hour for electrical energy is low as compared with the figures prevalent for plants of this size. It will be noted, however, that there are no overhead charges such as interest, depreciation and insurance. The Government carries no insurance, and because of the method of securing money for new apparatus by appropriation from Congress it is not necessary to make interest and depreciation charges.

The plant is now operating under the new conditions and all changes were made without any interruption to the service.

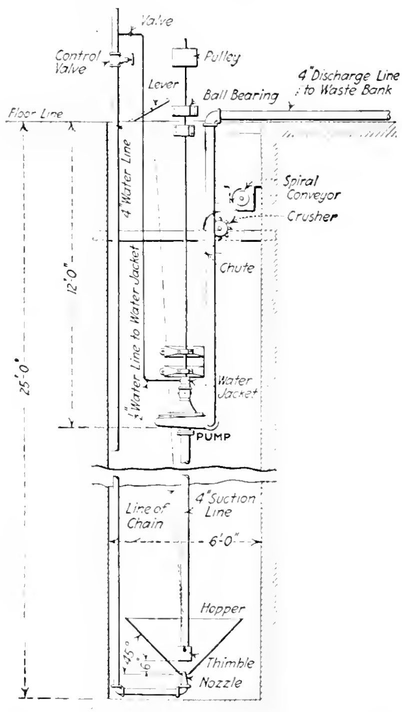
The work enumerated herein was designed by and the equipment installed under the direction of W. R. Metz, M. E., Superintendent of Buildings.

The old equipment was removed and the new equipment installed by the W. G. Cornell Co., acting as general contractors.

Dredge Pump Handles Ashes

By O. D. Havard

The Giant Portland Cement Company, Egypt, Penn., has developed a method of handling its boiler-room ashes which is believed to be new. It is an application of the centrifugal dredging pump which confines its use to plants having plenty of cheap water and those which waste the ashes within a few hundred feet of the building. The apparatus described was adopted, not because it was believed to be in all respects the best for the purpose, but because it was at hand.



Elevation of Apparatus for Handling Ashes

The plant consists of four 250-hp. and one 400-hp. water-tube boilers, hand-fired with anthracite barley coal. The grates are stationary and the ashes are drawn through the front doors. In front of the boilers and just under the floor is a 12-in. spiral conveyor; a small opening under each boiler door is provided for the ashes to enter. During cleaning, a stream of water is turned into the conveyor at its head, which serves to quench the heat and assist the conveyor by partially floating the ashes. The ashes are discharged into a crusher which reduces the clinkers to pieces of about two inches diameter. This crusher is home-made and consists of a cast-iron cylinder $8\frac{1}{4}$ in. in diameter by 12 in. long, with 1-in. spikes driven into tight-fitting holes and projecting 2 in. These rows straddle stationary spikes 2 in. apart. The cylinder is driven by a gear from the conveyor shaft. From the crusher the ashes drop into the well where a 4-in. horizontal-type dredging pump is mounted on the side wall, the weight of the shaft and runner being carried by a ball bearing at the floor level. The suction pipe is bent to come in the center of the well and terminates about a foot above the bottom. A 4-in. water pipe is led down and turned up, with a $2\frac{1}{2}$-in. nozzle directly under the suction and 6 in. away. The pump gland is water-sealed by a $\frac{1}{2}$-in. pipe tapped in above the 4-in. control valve. The water pressure at the valve is about 25 lb. The discharge, consisting of a 4-in. pipe, is led up and out to the waste bank. A thimble of 5-in. pipe is put over the suction and connected by a chain to the lever at the floor.

The process of operation is as follows: Drop the thimble before turning the ashes into the well to keep from obstructing the water pipe; run in all the ashes the well will hold. When ready to pump out, open the 4-in. valve four turns and open the gland water valve. Allow water to rise over the pump runner before starting. When the pump has run a short time on water only to insure the discharge pipe being clean, raise the thimble and allow the ashes to mix with the water. As high as fifteen cleanings have been put into the well before pumping out and have then been ejected in 30 min. The speed of the pump is 658 r.p.m. The variation of speed with head, as given by the manufacturer, is:

Head in Feet	Speed, R.p.m.	Head in Feet	Speed, R.p.m.
5	230	40	727
10	364	50	812
15	447	60	890
20	515	70	960
25	574	80	1000
30	630	90	1085
35	680	100	1145

Four horsepower is required for each ten-foot elevation.

The Colorado River Basin—A recent publication by the United States Geological Survey contains much information of value to all water users. All people interested in the water flowing in the streams of the great Colorado River basin should become familiar with the reports on the subject published by the United States Geological Survey. Such reports, covering the entire country, appear each year in twelve parts, as water-supply papers. Part 9 of this series is devoted exclusively to the Colorado River basin. This paper gives the results of measurements of flow made at about 140 regular river observation stations in the states of Colorado, Wyoming, Utah, New Mexico, and Arizona, and at about 60 miscellaneous points in those states. This information is necessary for the proper and economical installation and operation of water-power plants, irrigation projects, systems of municipal water-supply, works for the prevention of damage caused by devastating floods—in fact, all works that involve the use or control of water.

Editorials

Choosing a Profession

A correspondent recently asked us if we would advise him to continue studying electricity when he prefers steam engineering. We replied to this, as we would to any similiar question, that on general principles it is wise to study the subject which most appeals to one, and that anyone is most apt to succeed at the calling he likes best. It is better to be a successful steam engineer than a failure at anything else, no matter how much more attractive the other position might seem to be.

The young man's doubt arose from his feeling that steam was getting out of date. This, of course, is ridiculous, for the present at least. There is no denying that water power is gaining in use, and fortunately so, for the coal supply is certainly diminishing, but there will be plenty of fields for good steam operating engineers until long after this generation has finished thinking about it. There is a lot of truth in the verse foreword in this issue.

Cultivating an Engineering Hobby

The temptation to scatter one's energies over too great an area is particularly strong in engineering. The various branches of the profession are so inclusive, and the limitations of the individual are so marked, that the desire to make use of every possible opportunity to broaden one's knowledge of applied science often carries a man off his feet, so to speak, and results in a good deal of intellectual lost motion. Experienced men know how to guard against the dissipation of their resources, and one of the best methods is the cultivation of a hobby within the field of one's work.

By this is meant settling one's thoughts largely upon one special line of practice for a stated period, such as the rest of the winter and the early spring, and concentrating all one's extra efforts in the endeavor to acquire a real mastery of the selected subject. Thus, one man will decide to make a study of mechanical stokers, getting every catalog and reading every printed thing he can lay hands upon in this connection during the next two months or so, talking with men who operate, buy, sell and repair stokers, besieging the local public library for books containing matter on this theme, and absorbing data and information with might and main at every opportunity. Another man may prefer to take up the study of coal, following so far as he may the latest advances in its laboratory testing by the government, getting the new points of view regarding the volatile products of combustion, and perhaps reading about the methods of mining and preparing fuel for market. The next man may prefer to start a system of interchanging and comparing operating data among engineers of his acquaintance; another may want to master standard wiring methods or study the limitations of the gas engine and the producer.

All such work has real value. It should not blind a man to what is going on in the field as a whole, but giving direction to his special interests, it enables progress in mental acquisition to be cumulative and thus tends to lead one further into the mastery of a special subject than is possible by mere desultory reading and observation.

One engineer began a collection of station-operating costs in this way, and became so interested in the subject that he filled many pages of a notebook with comparative figures of the same and of different plants for three or four years. Much of the data were obtained from returns on file with the Public Service Commission of his state, and ultimately he was able to sell some of the material to outside interests who heard that he was assembling these costs, figured upon both unit and total bases. The material sold was all public property, being reported to the state annually, although few people knew of its existence, and in its study the engineer observed many interesting tendencies of practice, noting particularly the effect of larger generating units upon the cost of labor per kilowatt-hour, the influence of the day-load upon station efficiency, and other valuable data.

The best thing about thus cultivating what might be called a transient specialty is the enduring grasp of the subject which, if once acquired, never entirely leaves one high and dry in dealing with it later, but broadens the interest of the busy engineer in many inter-related branches of his profession.

Safe Piping

We have laws or ordinances regulating the use of boilers, the installation of electric wiring, plumbing and for safe building construction, yet for some unknown reason nothing in this direction has been accomplished with regard to the safety of steam piping. There is not even a rule making imperative the use of nonreturn valves at the boiler, and at both boiler and header when more than one boiler is used on pressure, possibly because these valves cost more than the ordinary globe or gate valves. The deciding consideration of all work seems to be the price; the safety of plant and humanity are usually secondary considerations.

Engineers seem to be averse to specifying exactly whose apparatus they require; such and such a make "or equal" is the usual way of putting it, possibly to avoid misinterpretation as to motive. However, more than one manufacturer's material is good, and why not mention more than one name, being particular in each case to specify each maker's classification? The pecuniary motive will at least be absent, the specification will be clearer to all interested, and such a practice will go far toward discouraging the sale of competing material now on the market, which is invariably sold as the "equal." It is also well to remember that ability of this "equal" material to fulfill its name is often left to the judgment of others, who may not be as conscientious as the engineers. The usual clause relating to a guarantee for defective material and workmanship is akin to locking the stable after the horse is gone. What good can the guarantee and actual replacing of defective material do to those physically injured?

It should be the aim of engineers to secure laws looking to the safety of piping work—in fact, the safety of all engineering work. Particularly where pecuniary interest can work against the safety of human life, the use of safety devices must be imperative. Rules as to layout and material, based upon past experience, must be enforced. This will also give the engineer a freer hand in designing for the penurious owner, whose sole aim is to get out as cheaply as possible.

Making the Most of Efficiency Instruments

In the report of the Committee on Prime Movers, presented at the Philadelphia convention of the National Electric Light Association, the point was made that a feeling exists among power-plant owners that the use of so-called "efficiency instruments" has been in a measure instructive, but that on the whole the results have been disappointing. The apparent reason set forth is that it was supposed that an operator with such an instrument before him would interpret the record and apply the obvious remedy for any poor results, whereas in reality, the plant does not realize from automatic station records the benefits which these might be made to yield. This is an important matter for consideration, in fairness to the busy operating engineer and in justice to his employer.

It is possible to load down a plant with automatic instruments whose records and indications give very little help to those in charge of the installation, but many plants suffer from the lack of instruments in important locations where moment-to-moment records would be of immediate help in operation. Without desiring to condemn any particular apparatus, unless equipment of this sort makes extremely direct measurements of a simple kind, its immediate usefulness to the operator is problematical except where such records have been interpreted by exhaustive comparisons with other periods, and this is a species of research work for which many engineers have no time. The interpretation of highly analytical records, in connection with some of the larger power stations, is therefore assigned to specially designated efficiency engineers having a technical knowledge of thermodynamics and chemistry, who are not burdened with routine operating duties and who report direct to the chief engineer all conclusions and recommendations, based upon a continuous analysis and study of the significant records of plant performance and personal knowledge of station apparatus and operating conditions. The distinction between operation and the analysis of plant data is a real one, and in companies where the output is large enough to warrant the expense, such a division of labor may be very useful.

In most plants, however, the control of production economy must rest in the hands of those who run the station from shift to shift, supplemented by occasional or, preferably, regular studies of performance by the engineering staff. Day after day, as the load varies, it is important to keep various pressures and temperatures, volumes and weights close to predetermined figures. For such work reliance upon steam gages, steam meters, coal scales, watt-hour meters, draft gages, and, almost above all else, upon thermometers located at strategic points, must take the place of so called continuous graphic test records whose significance cannot be taken without considering their relation to other and complex phenomena. To take the case of the carbon-dioxide recorder, for example, it should be clear that unless such data as this apparatus gives apply to the plant as a whole and not to a single boiler uptake, little immediate use can be made of the observations yielded.

In a nutshell, it is better to determine by tests what temperatures, pressures and volumes spell maximum plant efficiency for a given load and operating conditions and to try to approximate those readings, than to attempt to rapidly interpret highly complex indications drawn from portions of the station only, without having time to weigh and balance a wide range of such data. That is, efforts should be concentrated upon maintaining instrument readings known to be favorable to economy of operation, leaving the comparison of complex indications for the time when analyses can be studied at will.

There is room for establishing in many plants certain limits of operating efficiency expressed in maximum and minimum instrument readings, to stay between which should be the main object of the engineer's routine work. Prompt adjustment of fuel supply, water supply and air is more necessary in meeting the momentary conditions of service than drawing academic parallels between the percentage of ash in the pit of boiler No. 6 today and the same date of last year. For efficient handling of a plant one must have, first, a staff responsive to changes in its service conditions and competent to recognize the limits of efficient manipulation of individual apparatus, and second, the ability within the reach of the plant to draw from station history conclusions of value in meeting the demands of daily routine and emergency service.

Popularity among his fellows is a big asset to an engineer, but unless he has a commensurate amount of professional competency behind it, he's some day going to be a disappointment to himself and his friends.

The report of the commission which began about three years ago to investigate the use of electricity in the Netherlands states that the managements of a number of industrial concerns are of the opinion that it is most advantageous to furnish their own power. Many an American manufacturer found that out long ago.

On January 16, 1909, President Roosevelt sent to Congress a special message which seized the occasion of his veto of an apparently innocent bill granting water-power rights in Missouri to proclaim the discovery of a brand new trust—the Water-Power Trust—and to denounce it as a menace to the people which in a short time would be worse than even the Standard Oil Company.

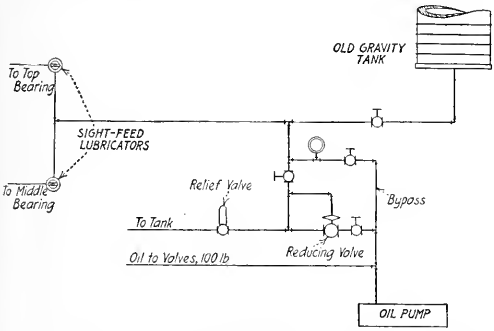
"The movement is still in its infancy," declared the President, "and unless it is controlled, the history of the oil industry will be repeated in the hydro-electric-power industry with results far more oppressive and disastrous for the people."

Subsequent developments have shown that it was no mare's-nest that the President unearthed. The "new trust" has proven itself powerful enough to hold up any legislation insuring the perpetuation of the people's rights in the water power of the country.

Correspondence

Changes Turbine Oiling System

The top and middle bearings of our 2000-kw. Curtis vertical turbine formerly received lubricating oil fed by gravity from an overhead tank. We were dissatisfied with this method of feeding and decided to take oil from the valve-oil line and run it through a reducing valve to the



PIPING FOR OILING SYSTEM OF VERTICAL CURTIS TURBINE

bearings. The hydraulically operated valves receive oil at 100-lb. pressure; the bearing-oil pressure is now maintained at 18 lb.

The changes made in the piping are shown in the sketch. The amount of lubricant fed to the bearing is controlled by manipulating sight-feed valves. We are well pleased with the change.

WILLIAM JOHNSON.

Newton Square, Penn.

Gas-Engine Cooling Water

The article on "Gas-Engine Cooling Water," by G. A. Field, in the Mar. 30 issue, contains some statements which do not seem to be in accord with good practice.

Discussing thermo-siphon cooling systems in small engines, he states that the bottom of the water tank should not be below the level of the water outlet of the cylinder jacket. He evidently means the jacket inlet opening, but even in this case the statement is not correct. It is usual in small engines to place the water tank so that the bottom is on a level with the engine base, with the tank outlet opening some three or four inches from the bottom, this being connected to the engine by the necessary pipes and elbows. It is safe to say that 90 per cent. of tank-cooled engines are arranged in this way and are giving perfect satisfaction.

In constructing an overhead tank special emphasis should be placed on the fact that, if the tank is placed at too great a height, there is danger of cracking the cylinder jacket. Many engines do not have a thick jacket wall and, stressed as it is by expansion, the jacket does not require many pounds of water pressure to fracture it.

I recall one installation where the cooling tank was placed on the roof of a three-story building, and the jacket fractured the first day the engine ran. When a new cylinder was received it also developed a crack after a few hours' run. It was decided that the hydrostatic head due to the height of the tank caused the trouble. This was partially demonstrated when the tank was placed at the rear of the engine room, and no further trouble was experienced.

L. H. MORRISON.

Fremont, Neb.

Changing Speed of Three-Phase Induction Motor

A two-speed, three-phase, 50- to 125-hp. induction motor, used to drive a rotary pump for pumping salt water into the fire mains for fire protection and for flushing purposes, was found to be too slow on the low speed to be of any use for flushing, as it gave only 30 lb. pressure on the mains and would not raise the water to the highest point in the flushing system. Therefore, the pump had to be run at the high speed all the time, using nearly 100 kw. and leaving the low-speed winding useless.

For the two different speeds, the motor has two windings on the stator, which are entirely independent of each other. The high-speed winding has 6 poles, with the coils connected on the inner end of the motor, and the low-speed winding had 10 poles, with the coils connected on the outer end. There are 90 slots in the stator, making

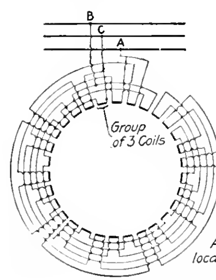


FIG. 1. ORIGINAL CONNECTIONS

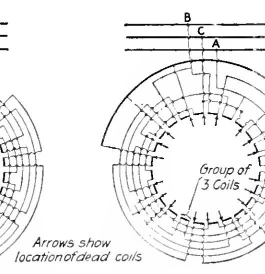


FIG. 2. CHANGED CONNECTIONS

it suitable for both a 6-pole and a 10-pole, three-phase winding, but not for an 8-pole winding, if all the coils were to be used.

After careful consideration it was decided to change the low-speed winding from 10 poles to 8, leaving 18 of the coils idle. A change was also made from delta to star connection and from series to parallel to increase the conductivity for the greater current necessary.

Fig. 1 shows the connections as they were for 10 poles, and Fig. 2 for 8 poles. The actual work of making the change was simple and cost only a few dollars, being paid for by the saving effected in less than a week's time.

The motor, when tested out at no load and at full load, was found to run just as well as when connected as a 10-pole motor with all the coils in use. It has been running almost constantly for over two years on the low-speed as an 8-pole motor, giving 45 lb. pressure on the mains, which is all that is needed, and using only 40 kw., thus making a saving of over 1400 kw.-hr. per day.

W. R. BANKHEAD.

Bremerton, Wash.

Corrosion of Iron and Steel Pipe

The conclusion of C. O. Standstrom in the issue of Mar. 23, page 416, that there is no vital difference between wrought iron and the steel used in its place will doubtless be concurred in by many who have attempted to distinguish between these two materials by ordinary tests. The reason is that the recent advances in the art of steel making have produced a steel which has nearly all the ordinary characteristics of wrought iron. It is tough, soft and stronger than wrought iron and does not harden when quenched from a red heat.

Of its many uses, the one of most importance to the engineer is in tubes and pipes. When welded pipe was first made, wrought iron alone was available, and for several years after the advent of steel its use was not even considered for welded pipe, but recently a pipe steel has been developed. Following are the comparative chemical analyses and physical tests of steel and wrought pipe as reported in the 1913 "Proceedings of the American Gas Institute:"

	Steel Pipe, per Cent.	Wrought-Iron Pipe, per Cent.
Chemical Analysis—		
Silicon	0.01	...
Sulphur	0.05	0.03
Phosphorus	0.10	0.17
Manganese	0.30	trace
Carbon	0.07	trace, irregular
Oxides (slag)	0.10	1.20 to 2.00
Physical Properties—		
Tensile strength	58,000 lb. per sq.in.	46,000 lb. per sq.in.
Elastic limit	34,000 lb. per sq.in.	28,000 lb. per sq.in.
Elongation	22 per cent. in 8 in.	12 per cent. in 8 in
Reduction in area	55 per cent.	25 per cent.

It will be noted that wrought iron contains considerable cinder, or slag, a peculiarity of wrought iron as made by the old puddling process. This slag can frequently be observed in a cross-section of iron pipe, especially with the aid of a magnifying glass. The tensile strength of the iron was measured when the sample was pulled longitudinally, and would be considerably less if pulled transversely to the direction of rolling, while the steel is practically of the same strength in all directions. A wrought-iron pipe, therefore, will fail under a lower bursting pressure than one of steel. At first, considerable difficulty was experienced in threading steel pipe, and dies which would cut a fairly good thread on wrought pipe would make a ragged thread and work hard on steel, but correctly designed dies with more rake and relief have been made.

As to their relative durability and resistance to corrosion there is much contradictory evidence, and it is difficult to separate fact from prejudice. One of the most generally accepted theories is that corrosion is due to electrolytic action, and such conditions seem to affect both iron and steel alike. It is true that structures made from puddled wrought iron have remained in good condition after exposure to the elements for more than a century. On the other hand, under certain conditions, iron and steel pipes installed together have been destroyed by corrosion within a few months, both being about equally affected.

With its passing it seems likely that wrought iron is esteemed more on account of its past reputation than because of any distinct superiority over the modern product. It is also quite probable that much of the so-called wrought iron supplied to the trade at the present time is in reality steel, and the satisfaction it gives depends upon its quality and whether it is adapted to the purpose for which it is used.

WILLIAM A. DUNKLEY.

Atlantic City, N. J.

C. O. Sandstrom states that there are no reliable data regarding the relative ability of iron and steel pipe to resist corrosion. The following is taken from the *National Bulletin:*

Prof. T. N. Thompson in March, 1906, installed alternate pipes of the two metals in a hot-water line, and at the end of a year discovered that steel pipe had approximately 7½ per cent. longer life than wrought iron under such conditions. In a similar test carried out by a committee appointed by the American Society of Heating and Ventilating Engineers with iron and steel pipe made by various companies, Professor Thompson reported: "We believe this test demonstrates that modern steel pipe of good quality is at least as durable as modern strictly wrought iron and is very much superior to a poor quality wrought iron in this class of work." (A. S. H. and V. Engineers, 1909.)

Tests carried on by the Pittsburgh Coal Co., H. C. Frick Coal Co. and others indicate that steel is at least equal to wrought iron in resisting corrosion (*Iron Age,* July 12, 1906).

In his textbook, "The Metallurgy of Iron and Steel," Stoughton, one of those who carried out exhaustive investigations, says: "The evidence goes to show that properly made steel corrodes no more than wrought iron."

J. Newton Fried, in his recent book, "The Corrosion of Iron and Steel," states that "it would appear, therefore, that when everything is taken into consideration there is practically nothing to choose between wrought iron and steel as at present manufactured" (page 286), and finally concludes with these words: "These and many other instances might be cited as illustrating the fact that good steel corrodes at much the same rate as good wrought iron" (page 288).

A. Sang, in a thorough résumé of the question, entitled "The Corrosion of Iron and Steel," says that "properly protected steel and iron rust to about the same extent, the steel doing so more uniformly," and adds, "The best quality of charcoal iron is practically as resistant as the best quality of steel used for similar purposes" (page 49), and in regard to pipe, says: "The carefully acquired experience of the largest manufacturers of tubes in the world, which induced them recently to abandon the manufacture of wrought-iron pipe, teaches that the use of steel in place of iron, at least in the United States, for the special purpose of tubing is to be preferred: the tendency of steel to pit is somewhat less than that of iron and it welds at the joint fully as well" (page 73).

Prof. Ira H. Woolson (*Engineering News,* Dec. 8, 1910) secured 89 samples of corroded pipe from seven bath houses in New York City. Of these samples 17 proved to be wrought iron and the remainder steel. He concluded: "In my judgment, from the evidence collected there was absolutely no difference in the corrosion of the two classes of pipe; they appear to be equally susceptible to the attack."

Dr. W. H. Walker (New England Water-Works Association, March, 1912), of the Massachusetts Institute of Technology, secured 64 samples of wrought-iron and steel pipe in adjacent service. These had been in use from 2 to 17 years. He reported that of the 64 samples 20 favor steel, 18 iron, 8 show no difference in corrosion and 17 no corrosion at all. These results again demonstrate that, taken on the average, there is no difference in the corrosion of iron and steel pipe. Conversations held with engineers in charge of plants during this investigation confirm the statement already made that a pipe is frequently called steel when corrosion is found to be excessive, while it is set down as iron if it rusts but little.

P. DeC. Ball (*Cold Storage and Ice Trade Journal*), in a paper read before the American Society of Refrigerating Engineers, made the following statements:

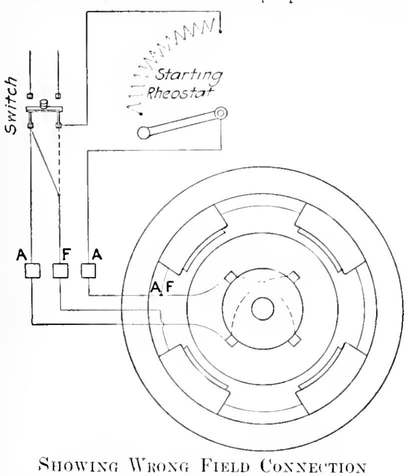
From 33 years of personal experience and observation constructing, erecting and operating ice-making and refrigerating machines, absorption and compression types, and using iron pipes for the first 14 years, and iron and steel pipes for the next 19 years, we are convinced that local conditions only govern the corrosion of pipes in refrigerating and ice-making machines, and that, chemically and mechanically, mild-steel pipe meets the requirements of the refrigerating engineers in all respects, and better than any other pipe for the reason that it is superior in point of finish, strength, strength of seam and uniformity of material.

James E. Noble.

Toronto, Ont., Canada.

Burned-Out Starter

On account of the liability of an operator to try to start a motor with the field switch open, it is not customary to install switches in the field circuits of motors. Where standard starting boxes are used, proper connections to



Showing Wrong Field Connection

the box insure that the line voltage will not be applied to the armature with the field unexcited, unless through some fault an open circuit exists. Where a starting box that does not handle the field current is used, it is safe to connect the field circuit across the service side of the line switch so that closing this switch will energize the field before the voltage can be applied to the armature, through the starting box.

Opening of the line switch then opens the field circuit, but also opens the armature circuit. Irrespective of the details of the field connection, however, if the motor fails to start when the starting handle is thrown, and flashing of the starter indicates the armature to be taking current, a piece of magnetic metal should be held to the polepieces to see if they are energized.

A manufacturer replaced a motor with a larger one which had been bought second-hand. Both motors had three leads. The shop had been rewired with larger wire for the new motor and the operator thought he had connected the second machine the same as the first. It developed, however, that he had connected the free field wire, as indicated by the dotted line, so that both ends of the field were connected to the same side of the circuit. The result was a burned starting box before he found out the trouble.

J. A. Horton.

Schenectady, N. Y.

Efficiency Engineers

The article in the Mar. 30 issue of Power on "Efficiency Engineers" sounds good. Why not get up a National Society of Efficiency Engineers based upon "deeds performed" as a degree of eligibility. Let applicants state the efficiency they are able to produce, as well as twelve sales or installations of merit on each account they may handle. There is a crying need for factory efficiency, particularly in this Southland, where negro labor is so prevalent. Thousands of plant managers are innocently losing a lot of money every twelve months, because they have never been "put wise" to a better way to run their plant.

J. S. Hoffecker.

Richmond, Va.

Strenuosity and Flywheel Risks

Referring to your editorial on "Effect of High Steam Pressure on Flywheel Risks," there is another phase of the current effort to get the greatest amount of energy out of a dollar's worth of engine which you might have mentioned. The amount of energy produced *per unit of time* depends upon the piston speed as well as upon the mean effective pressure, and the raising of the piston speed from the 600 ft. per min. usual 25 years ago to the 900 or more now not uncommon makes possible an increase in energy produced per second of 50 per cent. or more from this cause alone; and this energy, in addition to that due, as your editorial pointed out, to the increased boiler pressure, is available to accelerate the flywheel.

The fact that a flywheel running with a rim speed of 90 ft. per sec. has a smaller factor of safety than one running at 60 is too obvious to mention, yet it may be well to point out again that the stress from centrifugal forces increases as the square of the velocity, is $2\frac{1}{4}$ times as great at 90 as at 60 ft. per sec., and that if the engine runs away the wheel will burst in less time starting from a rim speed of 90 than of 60 ft. per sec.

P. H. Williams.

New York City

[In the case of a runaway engine the comparison is between the piston speed *attained* and not that at which the engine is rated. At the end of a number of seconds the piston speed of a runaway engine might be greater if the piston speed to start with were 900 ft. per min. than if it were 600, but it is not at all likely that it would be $1\frac{1}{2}$ times as much—EDITOR.]

Retubing Tubular and Water-Tube Boilers

With reference to J. C. Hawkins' article under this heading in the Mar. 9 issue, I wish to call attention to the statement, "The roller expander, which gives the best results and is generally used, consists . . ."

There was a time when the roller expander gave best results, because the prosser was undeveloped, but nowadays the sectional expander is more generally used. Both types have their good and their bad points. The roller expander does not bind the tube as firmly to the sheet as does the sectional tool, and there is always danger of rolling the tube too thin, although there is less danger of this with the sectional expander. The principal danger connected with the use of the sectional tool, according to the findings of the engineers of a large Eastern railroad, is that the tube sheet is liable to be cracked or unduly stressed. So far as I know, there are no other defects of this type A few years ago the roller expander was regarded as faster than the sectional, but the latter seems now to be well received.

W. F. SCHAPHORST.

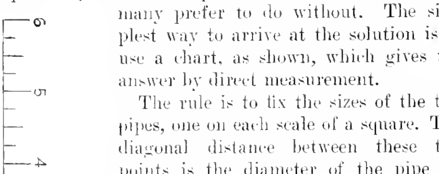
New York City.

Pipe Proportions

Every engineer at some time has to solve the little problem of the size of pipe required to equal two or more other pipes, and although this is not a difficult mathematical problem, it involves square root, and that is a thing many prefer to do without. The simplest way to arrive at the solution is to use a chart, as shown, which gives the answer by direct measurement.

The rule is to fix the sizes of the two pipes, one on each scale of a square. The diagonal distance between these two points is the diameter of the pipe required.

For example, for a pipe to equal two 2-in. pipes, measure the diagonal from 2 in. on one side of a square to 2 in. on the other; the result is $2\frac{13}{16}$ in., the size pipe which would be sufficient; but 3-in. is the nearest commercial size.



GRAPHIC METHOD OF PROPORTIONING PIPE SIZES

The line from 3 to 4 marked 5 is just a reminder of the method of constructing a square. With 3 on one side and 4 on the other and the diagonal distance 5, the first two lines will be at right angles to each other, and a square is produced. The result will be the same whether the pipes are measured in any linear unit or simply pieces of wood cut or marked to length, so long as they are equal to the pipe diameters.

Mathematically, the operation is to multiply the diameter of each of the smaller pipes by itself (as $3 \times 3 = 9$ and $4 \times 4 = 16$) and add them together ($9 + 16 = 25$); then any larger pipe the diameter of which similiarly multiplied by itself equals or comes nearest the other amount (as $5 \times 5 = 25$) will have approximately the same carrying capacity as the other two.

With piping of more than 6-in. diameter it is better to use the square root of the fifth power proportion, but this brings us up against a root again and so is outside the present scheme. Still, it gives 8 in. for a combination of two 6-in. pipes instead of $8\frac{1}{2}$ in. as given by the chart, so the chart is on the safe side.

R. HAMPTON.

Concepcion, Argentine.

Blowoff Piping Failures

Reference is frequently made to blowoff pipe failures and fatalities. Some of the fool things done are almost beyond belief. In a plant in which I operated the night shift the blowoff pipe was made up by screwing a nipple into the cracked outer end of the valve as far as it would go, then backing it out an indefinite number of turns on entering the other end into the next fitting. The piping was frequently disconnected and connected up again by the foregoing process. I chanced to step on the pipe in passing and it fell apart, after which I refused to blow down the boiler on account of this connection, so the owner gave it a "gingerly" little blow night and morning.

One day a new man, who was not familiar with the situation, nearly lost his life by opening the valve wide, which caused the pipe to give way. Such negligence seems to me to be criminal.

J. N. WOODRUFF.

West Liberty, Ohio.

Lubricating Commutators

I have been reading with interest the articles on the care and management of direct-current generators and motors and will mention a method of commutator lubrication that I have found entirely satisfactory. Since employing it I have had no trouble, whereas previously I had to give the commutators my attention every few hours. I take some $\frac{1}{2}$-in. square flax packing that has been treated with beeswax and tallow, cut a piece the length of the commutator bars and lay it on in front of the brushes, the friction holding it in place. A piece that will just fit between the end of the brush-holder and the commutator with a little pressure is better, for the friction holds it up against the brushes and there is enough lubricant from the packing to keep the brushes well lubricated. The wiping effect on the commutator keeps it clean and in a few days a nice polish will be observed.

After running the machine for a week or so, note if there is any copper wiping over the mica; if there is, simply take a sharp file and undercut the latter a little.

C. E. CUMMINGS.

Boulder, Colo.

Inquiries of General Interest

End Play of Crankshaft—What may be the causes of end play of the shaft of a vertical engine?

F. J. I.

Endplay may be caused by the crankpin brasses being out of line and bearing alternately on opposite ends of the crankpin, or to the shaft being out of line causing a wobbling motion of the flywheel, or in a single-crank engine, to lost motion in the crankshaft bearings.

Breakage of Firebox Stay-Bolts—What is the cause of breakage of the ordinary form of firebox stay-bolts?

J. M. B.

The chief cause is unequal expansion of the two sheets which are connected, one being usually in full contact with the fire and the other being heated only to the temperature of the confined water. This difference in temperature of the sheets gives rise to considerable relative motion between the two sheets resulting in formation of cracks in the stay-bolts near the inner surface of the sheets.

Use of Boiler-Tube Ferrules—What is the purpose of using ferrules on the ends of boiler tubes?

G. B.

Ferrules are used where the effects of expansion are severe upon the tube ends, as in locomotives and boilers having firebox tube sheets. Soft-copper ferrules are also used for filling tube-sheet holes that are too large for properly receiving the expansion of the tube ends. In cases where the tube material is especially weak or thin and is therefore likely to spring back when expanded, strong ferrules of hard brass or steel are driven inside of the tubes at the ends.

Position of Crankpin at Half-Stroke—In a horizontal engine does the crankpin stand vertically over or under the shaft when the piston is in the middle of its stroke?

W. L.

It cannot, for when the crosshead is in the middle of its stroke the distance from the center of the crosshead pin to the center line of the shaft is equal to the length of the connecting-rod, and as this is less than the distance from the center of the crosshead pin to the center of the crankpin when vertically over or under the center of the shaft, the crosshead must be at some distance from half-stroke toward the shaft for the connecting-rod to place the crankpin vertically over or under the shaft.

Maximum Capacity of a Boiler—What is meant by the maximum capacity of a boiler?

H. G.

The term refers to the boiler's highest rate of evaporation, or the largest number of pounds of water the boiler can evaporate per hour under stated conditions of temperature of feed water and pressure of steam generated. For purposes of comparison the evaporation under actual conditions is usually expressed in the equivalent evaporation from feed water having a temperature of 212 deg. F. into steam at atmospheric pressure, and as steam at that pressure would have the same temperature, the standard is generally referred to as "evaporation from and at 212 deg. F."

Degrees Baumé and Specific Gravities—In stating the densities of liquids, what are the relative values of degrees Baumé and specific gravities?

J. R. C.

For liquids heavier than water the relative values are given by the formulas,

Specific gravity = 145 ÷ (145 — deg. Bé.)

or

Degrees Baumé = 145 — (145 ÷ sp.gr.)

and for liquids lighter than water the relative values are given by the formulas,

Specific gravity = 140 ÷ (130 + deg. Bé.)

or

Degrees Baumé = (140 ÷ sp.gr.) — 130.

Case-Hardening Steel Governor Pins—How can steel governor pins be case-hardened?

M. G.

Case-hardening can be performed by heating the pin to a dull-red color, and after covering with pulverized cyanide of potassium or prussiate of potash the surfaces which are to be case-hardened, the operations of heating and coating are to be repeated. After the pin has cooled down almost to a black it is to be plunged in water and left until perfectly cold. In heating the pin the temperature should be raised gradually and so as not to burn or scale any wearing surfaces. The chemicals employed are violent poisons and care should be taken in handling them. A good way to coat the heated pin is to roll it over the pulverized chemical when spread out on a flat plate.

Resulting Temperature of Mixtures—What is the method of determining the resulting temperature of a mixture of two substances having different temperatures?

J. F.

The final temperature of a mixture of two substances of different initial temperatures is given by the formula:

$$T = \frac{(W \times S \times t_2) + (w \times s \times t_1)}{(W \times S) + (w \times s)}$$

in which

T = Final temperature of the mixture;
W = Weight of the hotter substance;
w = Weight of the cooler substance;
S = Specific heat of the hotter substance;
s = Specific heat of the cooler substance;
t_2 = Initial temperature of the hotter substance;
t_1 = Initial temperature of the cooler substance.

To Find Radius of Bumped Head—Knowing the diameter and height of bumping of a steam drum head what is the formula for determining the radius to which the head is bumped?

L. E. R.

In the figure if

R = The radius to which the head is bumped,
d = The diameter of the head, and
H = The height to which the head is bumped,

then

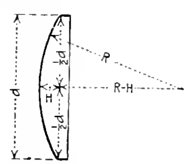
$$R^2 = \left(\frac{d}{2}\right)^2 + (R - H)^2$$

from which

$$2\,RH = \left(\frac{d}{2}\right)^2 + H^2,$$

or

$$R = \frac{d^2}{8H} + \frac{H}{2}$$



that is, the radius of bumping is equal to the square of the diameter divided by eight times the height of the bump, plus one-half of the height.

Boiler Efficiency—What was the efficiency of the boiler and grate using 14,278 lb. of coal having a calorific value of 13,000 B.t.u. per lb. for evaporation of 11,315 gal. of water from a feed temperature of 170 deg. F. into steam at 110 lb. gage pressure?

V. K. S.

Allowing 8⅓ lb. per gal., the water evaporated amounted to

11,315 × 8⅓ = 94,291.6 lb.

and the pressure of the steam was approximately

110 + 15 = 125 lb. per sq.in. absolute.

Referring to Marks and Davis' steam table it is seen that at 125 lb. absolute, each pound of steam contains 1190.3 B.t.u. above 32 deg. F., and as the temperature of the feed water was 170 deg. F., or 170 — 32 = 138 deg. F. above 32 deg. F., each pound of feed water must have received

1190.3 — 138 = 1052.3 B.t.u.

so that the total heat received from the boiler was

94,291.6 × 1052.3 B.t.u. = 99,223,050.68 B.t.u.

and as the coal contained

14,278 × 13,000 = 185,614,000 B.t.u.

the efficiency was

(99,223,050.68 × 100) ÷ 185,614,000 = 53.4 per cent.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Cookson Return Steam Trap

The illustration, Fig. 1, is a semisectional view of the new Cookson return steam trap. The device is compact, simple and positive, and it has a powerful valve mechanism. It is easily accessible, is regrindable, and the disk and reversible seats are made of monel metal.

The operation of the trap is simple. Fig. 1 shows it in a filling position with the boiler pressure on the outlet check valve. When the returning condensation is to go to the boiler, the trap is located three or four feet above the water line, so that the water will drain to the boiler by gravity. If any returns are below the water line the pressure on them must be sufficient to elevate the water into the trap.

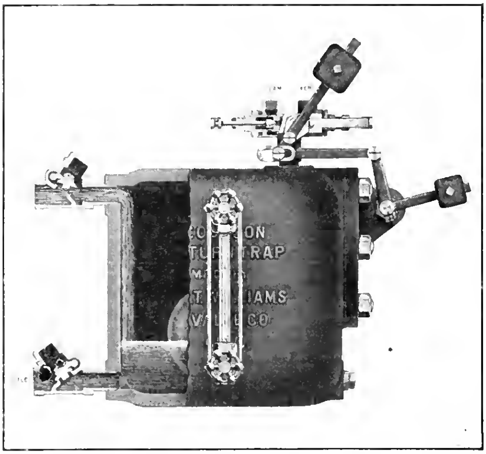


Fig. 1. Semi-Sectional View of the Trap

The accumulation of a given amount of water in the trap causes an upward movement of the float, Fig. 2, which communicates with the valve mechanism to the counterbalanced quadrant and connecting-rod. This action tilts the weighted valve lever, which opens the steam valve and lets the boiler pressure into the trap, closing the check valve on the inlet end. With the pressure in the boiler and in the trap equalized, the water flows to the boiler by gravity. After discharging, the floats drop and the weighted valve lever is tilted to its former position, automatically venting the trap of boiler pressure, and allowing condensation to flow into it until a sufficient amount has again accumulated to cause it to repeat the operation of discharging into the boiler.

To provide against any loss of steam a water seal of several inches remains in the trap after each discharge. Fig. 2 shows a detailed drawing of the trap and the valve-operating mechanism. The only thing in the body of the trap is the high-pressure float that actuates the valve mechanism. The design of the valve and seat makes it possible to regrind them while the trap is in operation. As the valve mechanism is on the outside of the trap it is easily accessible, and its movement indicates whether the trap is in operation or not. This trap is manufactured by the D. T. Williams Valve Co., Cincinnati, Ohio.

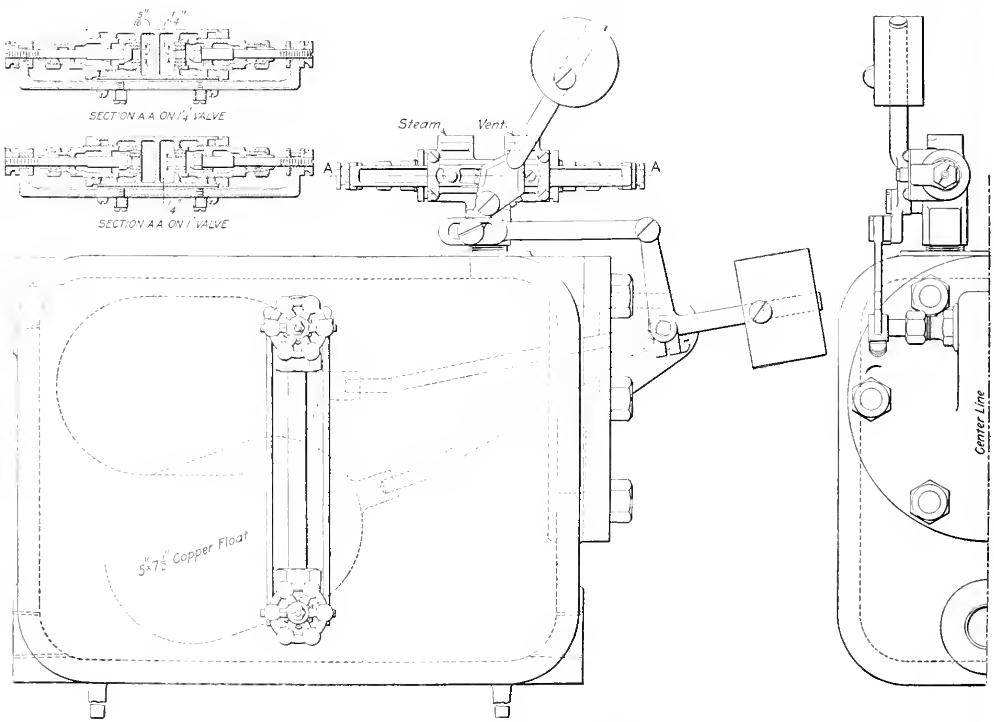


Fig. 2. Details of the Trap Construction

Fractional Horsepower Motors*

By Bernard Lester

SYNOPSIS—The development in the design and construction of the single-phase motor is traced from its origin to the present time, and the operating characteristics of the commoner types of single-phase motors are described and illustrated by the use of speed-torque curves.

During the last ten years the field for the use of fractional horsepower motors has increased enormously and many new devices have become available commercially. There have been three principal causes for this development in the small-motor field:

1. Efficiency engineering in every field of endeavor has brought to the mind of the public the realization of the saving that can be accomplished in time, labor and money by operating small appliances electrically.

2. Wide distribution of central-station circuits, primarily for the purpose of lighting, has greatly increased the possible field for the use of small motors.

3. The performance of the small motor as a reliable source of power and its proper application have established the confidence necessary to encourage the investment of time and money in the development of the industry.

Since single-phase, alternating-current distribution is so largely employed for lighting and, consequently, is available as a supply for small motor-driven machines, the development of a simple, reliable and efficient small single-phase motor has had a large share in the growth of this industry. Single-phase motors of the series, repulsion or induction type, or some modifications or combinations of these principal types, have been largely used.

Series Motor

The series single-phase motor, owing principally to its varying speed with change in torque, has a limited application. It can be safely used only where the load is rigidly connected to the driving shaft and where large variations in speed are permissible with variations in load. This type of motor is successfully used with fans attached to the motor shaft, and for exhausting or supplying air, as in the case of fan-type vacuum cleaners or forge blowers; also for portable electric tools, in which case the power is turned off when the tool is not in actual service. Its use, however, is limited to these or similar applications. A great advantage in the series motor, when especially constructed, is that it can be operated upon direct current or alternating current of most commercial frequencies and the same voltage, with speed-torque characteristics sufficiently similar to produce results generally satisfactory in motors of small capacity.

Repulsion Motor

The single-phase repulsion motor, which is a modification of the series motor, possesses in general the same limitations in regard to its speed-torque characteristics as the series motor. However, without load it does not attain the same dangerously high speed. Since the brushes are short-circuited, the interchangeability from alternating- to direct-current circuits does not exist.

Induction Motor

The single-phase induction motor possesses a speed-torque characteristic in which the speed holds practically constant under a varying torque. This is well suited to the large majority of small motor-driven machines, provided a means is supplied to bring the rotor up to a speed at which the inherent torque produced is sufficient to accelerate the load.

The split-phase induction motor is by far the most common type in fractional horsepower sizes. The most difficult problem has been in overcoming the absence of starting torque in the simple single-phase motor, and the principal steps in this development will be mentioned.

The first split-phase, self-starting motor was developed by Tesla and used for driving small desk fans, but was not employed generally for power service. Several years later, about 1893, single-phase induction motors of larger capacities were developed and used, but as there was no device for starting the motor, it had to be started by hand. Like any polyphase induction motor, when connected to a single-phase circuit and operated on one phase only, it would run in either direction, if started by some external force and accelerated to a point at which the torque developed by the primary of the motor upon the rotating element was sufficient to carry the rotor up to speed. The speed-torque curve of such a motor is shown in Fig. 1, curve AD. From 1893 to 1895 self-starting split-phase motors were designed with two windings in the primary—one for running and the other for starting. A phase splitter, consisting of a manually operated external switch and resistance, connected the primary windings to the supply circuit and inserted resistance in the starting winding. A phase displacement in this way existed between the currents in the two windings, which exerted a torque upon the rotor in starting, the starting winding and resistance being cut out as soon as the motor came up to speed. Later, motors were designed with starting devices supplied with a condenser in place of a resistance. This produced a greater angular advance in the phase displacement than was the case with the resistance starter. In this particular, therefore, a somewhat improved operating characteristic was obtained, due to higher power factor, the condenser remaining in the circuit while starting and running.

About 1898 single-phase induction motors were designed, which started as series motors. The secondary winding was similar to that of a series motor, the commutator bars being short-circuited as the armature accelerated, after which the motor ran as an induction motor. Shortly after this an advantage was found in starting as a repulsion instead of a series motor, since the motor so constructed could be connected externally for use either upon 110- or 220-volt circuits. Motors designed in accordance with this principle are now widely used, especially in sizes above ½ hp. An automatically operated centrifugal governor within the rotating element short-circuits the commutator bars. Curve B, Fig. 1, shows the speed-torque characteristics of such a motor while starting compared with that of the induction motor (curve AD). The line ab represents the speed at which the motor automatically switches from a repulsion to an induction motor.

Another development in the split-phase motor was in the use of an external clutch or clutch pulley. Owing to difficulty in obtaining sufficient starting torque to enable the motor to be used for other than accelerating very light loads, centrifugal clutches were used, allowing the rotor and shaft to accelerate to a point at which a liberal torque was exerted

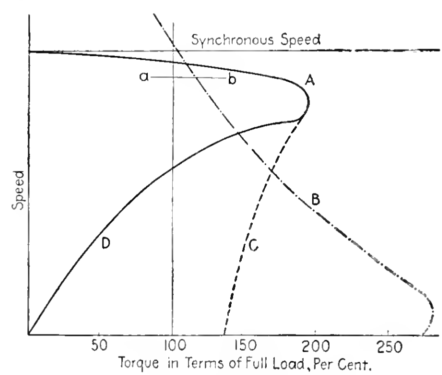


Fig. 1. Speed-Torque Curves

by the rotor; at this point the clutch took hold and applied the load to the motor. Within the past few years marked improvements have been made and sufficient starting torque can now be obtained without the use of a centrifugal clutch, for many classes of service. A light, high-resistance starting winding, in addition to the running winding, is used. Curve AC, Fig. 1, shows a typical speed-torque of such a motor. This starting winding is cut out by means of a centrifugally operated switch placed within the motor and at a speed slightly below that corresponding to full load.

*Excerpts from paper presented at Cleveland Section, A. I. E. E., Mar. 19, 1915.

It is interesting to note that small-motor engineers encounter almost identically the same problems as those which apply to larger industrial motors, in so far as cycles of operation and speed-torque requirements are concerned. For instance, in the application of small motors to washing machines with wringers, the wringer is the limiting feature, taxing the motor with sudden peak loads. This application may well be compared with a motor-driven rolling mill. The motor-driven meat grinder compares closely with the motor-driven pulp-mill beater, and the coffee grinder with the rock or stone crusher. In the design of high-speed motors for fan-type vacuum cleaners, the problems closely parallel those of the high-speed turbo-blower.

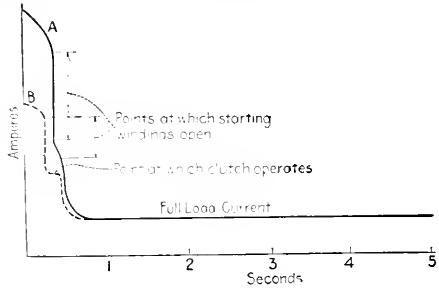


FIG. 2. CURVES SHOWING STARTING CURRENT

In applying split-phase motors, aside from the general characteristics outlined elsewhere, special attention must be given to those characteristics of starting torque, pull-out or maximum torque and temperature rating. The starting torque varies approximately as the square of the impressed voltage; consequently, any reduction in the voltage of the circuit produces more than a proportional reduction in torque. Furthermore, the starting current of split-phase motors materially exceeds the full-load running current. This factor, in addition to light wiring or insufficient transformer capacity, often results in a reduction in starting torque. Good practice in small-motor application provides that the motor should be able to start the driven machine when the impressed voltage is as low as 20 per cent. below the rated voltage. A centrifugal clutch is often incorporated in the design of the motor, not only to insure an ample starting torque and reduce the effect of the current taken during starting, principally by cutting down the time during which it is taken, but also to provide an element of flexibility in the case of a machine rigidly connected to the motor. The clutch will slip in the event of sudden or extreme overload, thus protecting the combined unit.

New Federal Employment Offices

The Department of Labor, through the Division of Information of the Bureau of Immigration, has recently established distribution branches throughout the country for the purpose on the one hand of developing the welfare of the wage earners of the United States and improving their opportunities for profitable employment, and on the other hand of affording to employers a method whereby they may make application for such help as they need, either male or female, citizens or alien residents, and have their wants supplied through the distribution branches. No fee is charged employer or employee for this service.

The following is a list of the headquarters, together with the states comprising the zone or jurisdiction over which they, respectively, have control:

Zone No	Location of Branch	Local Address	States or Territory Controlled
1	Boston, Mass	Long Wharf.	Maine, Massachusetts, Rhode Island.
2	New York, N. Y	United States Barge Office	New York, New Jersey, Connecticut, New Hampshire, Vermont.
3	Philadelphia Pa	Gloucester City, N J....	Pennsylvania, Delaware, West Virginia.
4	Baltimore, Md	Stewart Building	Maryland.
5	Norfolk, Va...	119 West Main Street....	Virginia, North Carolina.
6	Jacksonville, Fla.	Federal Building..........	Florida, Georgia, Alabama, South Carolina.
7	New Orleans, La	Immigration station......	Louisiana, Mississippi, Arkansas, Tennessee
8	Galveston, Tex...	Immigration station.....	Texas, New Mexico.
9	Cleveland, Ohio	Post Office Building. . .	Ohio, Kentucky.
10	Chicago, Ill	845 South Wabash Ave	Illinois, Indiana, Michigan, Wisconsin.
11	Minneapolis, Minn	Federal Building......	Minnesota, North Dakota, South Dakato.
12	St Louis, Mo.	Chemical Building....	Missouri, Kansas, Oklahoma, Iowa.
13	Denver, Colo.	Central Savings Bank Building	Colorado, Wyoming, Nebraska, Utah.
14	Helena, Mont..	Power Building.....	Montana, Idaho.
15	Seattle, Wash	Fifteenth Avenue, West and Blaine Streets..	Washington.
16	Portland, Ore	Railway Exchange Building.	Oregon.
17	San Francisco, Cal	Angel Island..............	California, north of the northern boundary of San Luis Obispo, Kern, and San Bernardino Counties; also State of Nevada.
18	Los Angeles, Cal	Post Office Building	California, south of the northern boundary of San Luis Obispo, Kern, and San Bernardino Counties; also State of Arizona.

All of the postmasters throughout the United States are coöperating in this work by distributing application blanks both to employers and employees. The appropriate blanks may therefore be had on request to any postmaster. However, in those cities designated as zone headquarters application for blanks or information should be made direct to the Inspector in Charge of the Distribution Branch at the office of the Immigration Service at the address indicated in the foregoing table.

Western Hydro-Electric Development

The Montana Power Co., which is attempting to enter the Cœur d'Alenes, Idaho, in competition with the Washington Water Power Co., has 101,000 hp. of hydro-electric plants in operation, 120,000 hp. under construction, 127,000 hp. of undeveloped water-power sites and 8000 hp. of steam reserve. A second unit of Prickly Pear Valley irrigation project will be completed this spring and an additional 3500 acres served with water in 1915.

During the last three months of 1915, according to the report for the year ending Dec. 31, 1914, the company expects to receive a large additional revenue from railway electrification now under way on the Chicago, Milwaukee & St. Paul Ry. The Great Falls hydro-electric plant, which will have an ultimate capacity of 80,000 hp., will be in operation in July, and four of the six units of installation will be completed in the present year. Current is expected to be furnished from the Thompson Falls plant by June. Two units will be installed this year and two added as demanded. About 75 per cent. of the work at these two developments has been completed The Hauser Lake plant has been increased to 34,400 hp. and the Black Eagle plant to 5100 hp. Sixty-seven miles of additional transmission lines were placed in operation in 1914.

Convention Dates for 1915

National Association of Stationary Engineers, Columbus, Ohio, Sept. 13-18.

American Order of Steam Engineers, Atlantic City, N. J., June 21-25.

Universal Craftsmen Council of Engineers, Rochester, N. Y., Aug. 3-7.

Canadian Association of Stationary Engineers, Hamilton, Ont., July 27-29.

N. A. S. E. STATE CONVENTIONS

California	San Francisco	May 27-28
Colorado	Denver	Aug. 6
Connecticut	Hartford	June 25-26
Illinois	Decatur	May 26-28
Indiana	Richmond	June 9-12
Iowa	Clinton	June 2-4
Kansas	Wichita	May 5-7
Kentucky	Lexington	June 10-12
Michigan	Jackson	June 23-25
Minnesota	Mankato	July 7-9
Missouri	St. Louis	May 19-21
New England	Holyoke, Mass.	July 7-10
New Jersey	Trenton	June 3-6
New York	Auburn	June 11-12
Ohio	Columbus	Sept. 12-13
Pennsylvania	Pittsburgh	June 18-19
Texas	Dallas	....
West Virginia	Clarksburg	....
Wisconsin	Sheboygan	July 22-24

The Temperature at Which Water Boils depends on the pressure upon its surface. At 1 lb. absolute its highest temperature is 102 deg. F.; at 14.7 lb., 212; and at 300 lb., 417.5 deg. (see steam tables).

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Safeguard Children Against Wires—An electric-power company which knew that boys were accustomed to play on a wall near an electric wire carrying a dangerous voltage was bound to maintain the wires in safe condition, and, therefore, is liable for the death of a boy who came in contact with a wire where it was uninsulated, according to the decision of the New York Supreme Court announced in the case of Meehan vs. Adirondack Electric Power Co., 150 "New York Supplement," 714.

Care in Handling Electricity Standardized—The degree of care required in the maintenance of electric wires is declared by the Washington Supreme Court, in the recent case of Card vs. Wenatchee Valley Gas & Electric Co., 137 "Pacific Reporter," 1047, to depend upon the character of the current carried, slight care being sufficient where the current would not injure persons coming in contact with it and the highest care being required where the current would cause death or serious injury. The court finds that the jury were warranted in finding that an electric-power company was negligent in failing to insulate a high-power wire which was strung only 17 ft. above the land of one who was killed through inadvertently bringing a pipe in connection with the wire while repairing an irrigation ditch.

Proving Negligence in Explosion—In suits for injuries from boiler explosions, it often becomes difficult to establish the cause as a basis for holding the owner responsible if it appears that the accident was due to negligence attributable to him. This question arose in the recent case of Gill vs. Brown (169 "Southwestern Reporter," 752), which was passed upon by the Tennessee Supreme Court, and it was sought to hold an employer liable for injuries sustained by plaintiffs while at work in the former's sawmill, caused by the explosion of a steam boiler, on the theory that the mere occurrence of the explosion raised a presumption of negligence, in the absence of affirmative proof to the contrary on the employer's part. But the court held that the mere fact of an explosion does not change the rule of law which places the burden on the plaintiff in every personal-injury action to clearly establish the fact that the injury complained of was produced by some negligence attributable to the defendant. The court, however, held that proof in this case that the boiler was very old (the evidence tended to show that it had been used for 40 years) and the finding of several rusted rivets in the wreckage warranted a finding that the boiler had been negligently permitted to remain in a dangerously defective condition.

PERSONALS

Alfred Kauffmann is now vice-president of the Link-Belt Co. in charge of operations at Indianapolis. Mr. Kauffmann served in the engineering department at Philadelphia for a number of years, from which he was promoted to take charge of the erection work of the company. He was later transferred to the sales department, looking after the coal-mining business in the East and particularly in the West Virginia field. His many friends will be glad to learn that in recognition of his competent and able work he has been elected vice-president of the Link-Belt Co.

ENGINEERING AFFAIRS

The American Iron and Steel Institute will hold its eighth general meeting at the Waldorf-Astoria, New York, on May 28 and 29. The program, which will be announced in the near future, will contain only a few formal papers in order to encourage informal discussion.

The Detroit Engineering Society announces the following meetings: May 7 Mr. John O'Connor, Jr., of the Mellon Institute of Industrial Research, will speak on "Some Points in the Indictment of the Smoke Nuisance;" May 21 Mr. H. M. Brinckerhoff is expected to give his deferred talk on the "Detroit Traffic Situation."

Boston Association No. 12, of the National Association of Stationary Engineers, will celebrate its twenty-first anniversary with a ladies' night at 995 Washington St., on the evening of May 3. All members of the N. A. S. E. and their families are invited to be present.

Pratt Institute, Brooklyn, N. Y., exhibits the work of day students on Apr. 29, 2 to 10 p.m.; Apr. 30, 10 a.m. to 10 p.m., and May 1, 10 a.m. to 5 p.m. The students will be engaged at their regular work, and the engineering public is invited to inspect especially the methods and equipment of the School of Science and Technology.

International Engineering Congress—Volume II of the Transactions of the International Engineering Congress to be held in San Francisco, Sept. 20 to 25, will comprise two series of papers, one on the subject of waterways and one on irrigation. The former subject will be treated under four general topics with possibly two additional. These topics cover the general field of the province of waterways in internal commerce, economic aspects, physical features, natural waterways, towage and propulsion. Irrigation will be treated under 11 topics covering: Methods of handling irrigation enterprises; duty of water; relation between demand and supply; underground sources; stream sources; tail water from hydro-electric plants; regulations for use; methods of charge; metering; drainage; dams in general; and also recent developments in India and in the Argentine Republic. This volume will comprise from 20 to 25 original illustrated papers, together with contributed discussions. The transactions of the Congress as a whole will include from seven to nine other volumes, covering the various fields of engineering work. Membership in the Congress with the privilege of purchasing any or all of the volumes of the proceedings is open to all interested in engineering work. Full particulars may be obtained from W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

BOOKS RECEIVED

DIRECT-ACTING STEAM PUMPS. By Frank F. Nickel. McGraw-Hill Book Co., Inc., New York. Cloth; 258 pages, 6x9¼ in.; 218 illustrations; tables. Price, $3.

ENGINEERING ECONOMICS. By J. C. L. Fish. McGraw-Hill Book Co., New York. Cloth; 217 pages, 6x9½ in.; illustrations; tables. Price, $2.

NEW PUBLICATIONS

STEAM TURBINES. By James A. Moyer. Published by John Wiley & Sons, New York, 1915. Second edition. Cloth; 376 pages; 6x9 in. Price, $3.50.

While intended as a manual for those operating, designing or manufacturing steam turbines, an outline of elementary thermodynamics and of the use of entropy and velocity diagrams is given. The part of the text relating to the design of nozzles and blades is valuable as an explanation of the theory, but the lack of detailed proportions and dimensions prevents its being of much use to designers. Since the first edition was issued, new applications of turbines have come into use, and accordingly, in the second edition Professor Moyer has either added or revised chapters on low-pressure, mixed-pressure and bleeder turbines. The essential elements of commercial types of turbines are clearly described and the methods of testing explained. With the exception of the numbering of the illustrations, the arrangement of the book is excellent. But to look at Fig. 192, which precedes Fig. 206, in turn followed by Fig. 195, gives the impression that the illustrations, in reality a most valuable part of the book, were an after-thought. The volume also contains interesting chapters on power-plant costs, an outline of plant design, and a theoretical discussion of gas turbines.

POURING OF BABBITT METALS

In a treatise on the "Pouring of Babbitt Metals," the Syracuse Smelting Works, of Brooklyn, N. Y., offers suggestions which every engineer would do well to follow: Among other things it says:

Better service may be obtained if you will learn that it is of the utmost importance to pour babbitt metals at a low temperature.

When practical, take the chill off the mandrel and shell by warming, as this will dry off the moisture which causes blow-holes, and also makes the metal flow better.

On the subject of remelting metals is the following:

Instructions are generally given to stir before pouring. Those who give these instructions intelligently do so because the tendency is to pour metals too hot and the stirring lowers the heat.

This dispels the idea which many engineers have, that the purpose of stirring the molten metal is to reunite the separated alloy.

To determine whether the melted metal needs cleaning, it advises that the surface be examined while it is at a fair pouring heat. If fine, spider-web lines appear on the surface after skimming, the metal is clean.

OXYACETYLENE WELDING AND CUTTING. By Calvin F. Swingle, M. E., author of "The Twentieth Century Handbook for Steam Engineers and Electricians," etc. Chicago: Frederick J. Drake & Co. Size, 4½x6¾ in.; 185 pages; 76 illustrations; indexed. Price, cloth, $1 net; leather, $1.50 net

This volume deals with many types of generators and portable apparatus in detail, together with the chemical properties and considerations of the gases used. There are numerous illustrations of different types of equipment, with notes on the mode of operation.

The chapters on torches, their management and characteristics are instructive, and useful information is given relating to the consumption of gas and methods of handling, with illustrations, weights and dimensions of torches in general use. Actual welding and cutting work could with advantage have been treated at greater length and illustrated with practical examples giving information on the work done by others and conclusions to be drawn therefrom. The impression that this mode of welding is applicable to everything should be avoided. While its uses are increasing, other forms still have a very large field where the oxyacetylene method is too costly and uncertain in its results. Costs of operation could also have been dealt with to advantage. The illustrations are not all that could be desired, but the book is well indexed; and no doubt will find favor among those interested in the apparatus required but who do not wish highly technical descriptions.

Though the names of some of the makers of apparatus are included, they are few. That of the Davis-Bournonville Co. is an especially conspicuous omission, in view of the great amount of pioneer work which this company did in introducing the art into this country. Some authors inject too much advertising into their books to have them wholesome, but this one seems to have gone to the other extreme. Credit should be given where credit is due, especially when it will be of actual interest to the reader.

PREVENTING LOSSES IN FACTORY POWER PLANTS. By David Moffat Myers. New York: The Engineering Magazine Co. Cloth; 5¼x7½ in.; 560 pages; 68 illustrations. Price, $3.

That the saving of coal in our industrial plants is necessary for the present generation, as well as those to come, can hardly be denied. The monetary saving effected today, while enabling us to procure certain improvements in our plants, to give better working conditions to our employees, higher wages, and increased dividends, is only one side of the question; possibly that uppermost in our minds, but the consequent conservation of our available coal fields is of greater importance to posterity.

Power-plant efficiency has made considerable progress in the past few years, but still not as great as efficiency applied to other lines of business, possibly because the efficiency engineer meets with greater obstacles in this field. It is usually easy to convince the manager of an industrial plant of the advisability of installing a machine that will enable him to cut down his labor or double his output; it is simply a matter of the cost of the machine installed and its earning power.

When the efficiency engineer seeks to impress this same man with the saving that can be effected through the employment of proper methods applied to the coal pile, he usually meets with considerable uphill work, and frequently with ill-concealed skepticism. Managers and owners, when approached on this subject, are prone to reply that they have made very good arrangements with their coal dealer, that they have good firemen, the steam they are allowing to go up in the air does not amount to much anyway, and kindred other replies only too familiar to engineers that have tried to lead them back to the path of efficiency. Some again, will realize that there is waste in exhausting to atmosphere, the use of bare steam pipes, the use of long and badly arranged shafting, the unintelligent handling of boilers and coal. These men are indeed wise and, regrettably, too few.

The work under review deals with this important subject in a clear and illuminating manner and should be of great benefit to all engaged either in the owning, operating, designing or rehabilitating of power plants, great or small. The theory and practice are ably explained. Every item of loss, with its consequent result, is traced in successive steps from its origin back to the coal pile. Methods of prevention, together with actual examples from the author's wide experience, are carefully shown.

The engineers at present exploiting this field, or those who may have this intention, would do well to read this work and apply the principles therein. Many useful tables and tabular results of actual tests are given.

The author undoubtedly intends the volume to be read in its entirety, as no index is provided. The subject, to be thoroughly appreciated, must be completely read.

BUSINESS ITEMS

Arthur G. McKee & Co., contracting engineers, of Cleveland, Ohio, have issued an attractive brochure, elaborately illustrated with examples of their work.

The Indiana Steel Co., Gary, Ind., has installed "Diamond" Soot Blowers, made by the Diamond Power Specialty Co., Detroit, Mich., on 26 boilers.

The Chicago Pneumatic Tool Co., Chicago, Ill., has removed its New York office from 50 Church St. to 52 Vanderbilt Ave., and its Boston office from 191 High St. to 185 Pleasant St.

L. R. Merritt & Co. has removed its office from 95 Liberty St. to larger quarters in the Vanderbilt Concourse Bldg., 52 Vanderbilt Ave., New York. This company represents the Brownell Co., Springfield Boiler & Mfg. Co., Craigs Ridgway & Son Co., Coppus Engineering & Equipment Co., Advance Pump & Compressor Co., James McMillan & Co.

The Harrison Safety Boiler Works, 17th and Clearfield St., Philadelphia, Penn., is sending out Cochrane "Engineering Leaflet" No. 18. This 48-page booklet contains an article by W. S. Giele entitled "Laboratory for Investigating and Testing Liquid Flow Meters of Large Capacity" and an article by James Barr, B. Sc., entitled "Experiments Upon the Flow of Water Over Triangular Notches." Copies are mailed on request.

Bird & Son, E. Walpole, Mass., has recently ordered of Builders Iron Foundry, Providence, R. I., a venturi meter with type M indicator-recorder for boiler feed service. This constitutes the fourth venturi meter installed by this company for measuring boiler feed water. The Inland Steel Co., of Indian Harbor, Ind., recently ordered an 8-in. venturi meter tube with type M register-indicator-recorder for boiler feed service.

"Retail Coal Pockets, Third Edition" is now being distributed by the Guarantee Construction Co., 142 Cedar Street, New York. Specialists in constructing buildings and apparatus for handling coal and ashes for power plants. This 32 page 6 by 9 booklet illustrates many pockets recently erected by them, describes modern coal handling methods, and explains which are most suited to various conditions. A copy will be mailed on request.

Recent installations of American standard copper coil feed water heaters, made by the Whitlock Coil Pipe Co., Hartford, Conn., include: Hainesport Mining & Transportation Co., Philadelphia, Penn., 600-hp. for its dredge "Philadelphia;" Lake Champlain Transportation Co., Whitehall, N. Y., 100-hp.; L. M. Hartson Co., No. Windham, Conn., 50-hp.; Metropolitan Water and Sewerage Board, Boston, Mass., 150-hp.; Chatham Bars Inn, Chatham Bars, Mass., 80-hp.; Brawn-Willard Co., Portland, Maine, 100-hp.; Rhode Island Mill, Spray, N. C., 500-hp.; Northwestern Electric Co., Portland, Ore.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Opportunities, Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale,** 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A.M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

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POSITIONS OPEN

MASTER MECHANIC for rolling mill. P. 487, Power.

A CENTRIFUGAL PUMP DESIGNER with experience in designing high-speed pumps of small and medium sizes for high- and low-head service; applicants must state fully their experience, age and salary expected. P. 491, Power.

POSITIONS WANTED

CHIEF ENGINEER, employed in central station; seven years' experience with engines, turbines, dynamos, boilers; married; age 30. P. W. 488, Power, Chicago.

POWER

Vol. 41 NEW YORK, MAY 4, 1915 No. 18

"Push, Don't Knock"

Written by
L. R. W. Allison,
Newark, N. J.

A FAMILIAR PHRASE *that has many times stared at us from a conspicuous position upon a door; three simple words that are almost invariably passed by with entire thoughtlessness, attributing the significance directly to only the entrance thus slightly guarded.*

BUT stop to analyze, consider more fully the meaning beyond the external marking and we find that the expression strikingly pertains to each one of us and our daily endeavors, conveying a teaching of sterling worth.

"Push, Don't Knock" has its limits on the door of the office, it has *no* limits on the door of our future. It is erasible from the former, but it is stamped *indelibly* on the latter.

Push at the door of the office and it opens just so far; push at the door of personal advancement, and the more persistent and energetic the push, the wider does it extend.

In this sense, *push* is *progress*, and progress is *going forward*. The engineer cannot remain as stationary as his engines, he *must* move, either slipping *up* or *down* the ladder of bigger things.

There are two general classes of men, the *pushers* and the *pushless*, one drives forward and keeps his step, the other *is driven* forward and falls backward. One *uses* his best efforts, the other *abuses* them.

The motto of the progressive engineer commences with "Push" and includes "Don't Knock." This man doesn't cry for a chance for advancement, he tries for it, and with that real ambition and confidence in his own ability that gets there. The engineer with push in his makeup embraces every opportunity offered him, and if it *isn't* offered, he *makes* it. he shows right in his own plant what *he* can do.

Opportunity is like the live steam line under heavy load, it's never empty, it's never used up. The pressure back of it is the enthusiasm that is put into the work of every day. That is the real power on the job.

To *knock* is the easiest thing on earth; everyone can grumble, whine and complain and "knock" his associates, his boss and his plant. It doesn't require any real ability to do this—it's boy's play.

But did you ever see an engineer who is alive to every chance for advancement spend valuable time in "knocking"? He's too busy with something to waste his efforts in nothing.

The long running hit in the game of life is the real demonstration of your real superiority. Consider it from any angle, you will find that it is this alone that counts.

To "Push, Don't Knock" is the creed of energy; it's the small beginning that offers a big ending; it doesn't require deep thinking to see it. It's the handwriting on the door of opportunity for the man who will push it open wider and wider without knocking.

Federal Power House, Boise, Idaho

By A. P. Connor

SYNOPSIS—This hydro-electric power plant has been built to supply electrical energy for constructing the Arrow Rock dam about fifteen miles distant. There are three 625-kv.-a. vertical-type generators, each with its exciter coupled to the upper end of the generator shaft. The voltage of the main units is 2300, which is stepped up to 22,000 volts for transmission. When the dam is completed the plant will be used for supplying energy for local use.

The project which the United States Reclamation Service is undertaking for irrigation purposes at Boise, Idaho, has in reality three natural subdivisions, one being in the valley of the Payette, the second in the Boise Valley and the third in the valley on the north side of the Boise River. The reference in this article is to the part of the project which makes use of the Boise River for power purposes.

The dam across the Boise River, Fig. 1, which makes its waters available for irrigation and power purposes, is situated about eight miles above the City of Boise. The dam raises the water level 33 ft. and diverts water into a canal extending 23 miles to Indian Creek, the channel of which is then used for about nine miles, where the water is then directed into another canal, eight miles long, and which terminates in the Deer Flat Reservoir. The possible power development is estimated at 15,000 hp. The power possibilities from the various streams in the vicinity of the project are great, and a number of hydro-electric plants have been constructed.

The turbines of the Boise hydro-electric plant, Fig. 2, rest on the discharge tunnels, thus utilizing short draft tubes, Fig. 3. The thrust bearings are just above the wheel pits, and the alternators rest on the main floor of the generator room. There are three vertical-type, alternating-current generators, each of 625-kv.-a. capacity, with exciters mounted on the end of each shaft. The units generate 2300-volt three-phase current at 60 cycles, and this is transformed to 22,000 volts for transmission to the Arrow Rock dam. The generators are synchronized on the 22,000-volt side of the transformers, and provision is made for operating them in parallel. The generators are of the revolving-field type and have a rating of 500 kw. at 80 per cent. power factor with a speed of 180 r.p.m.

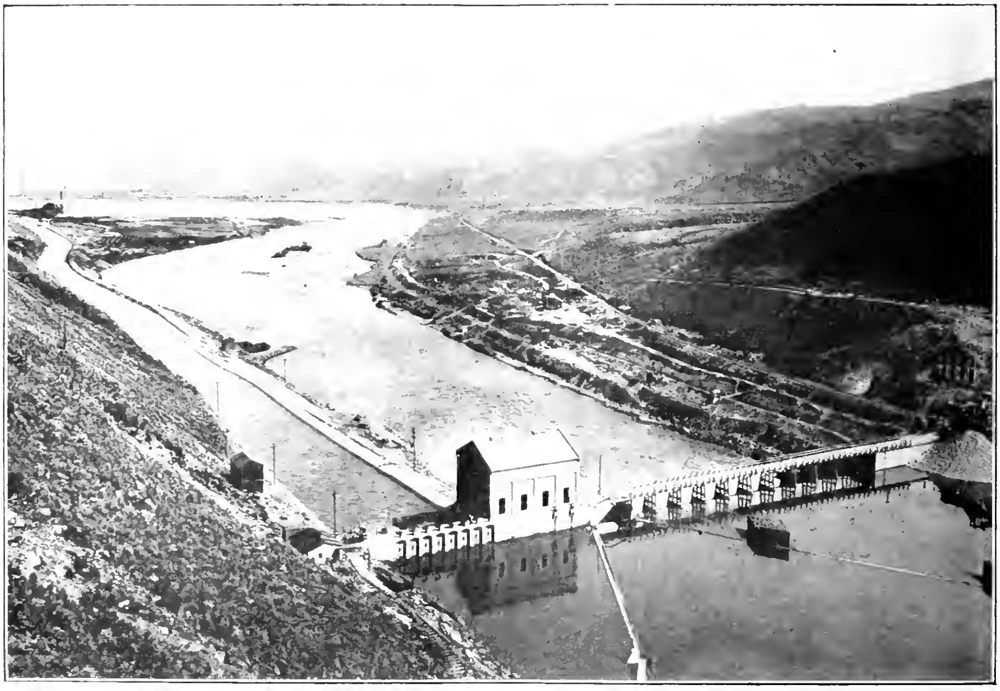

Fig. 1. Dam and Power House at Boise River

The exciters are supported by the top spiders of the respective alternators. The capacity of each is sufficient to furnish the maximum field current for two alternators, plus 10 kw. for local or other requirements. The exciters are designed to generate direct current at 125 volts. A regulator is used to control the generator voltage. Fig. 4 is a plan of the plant.

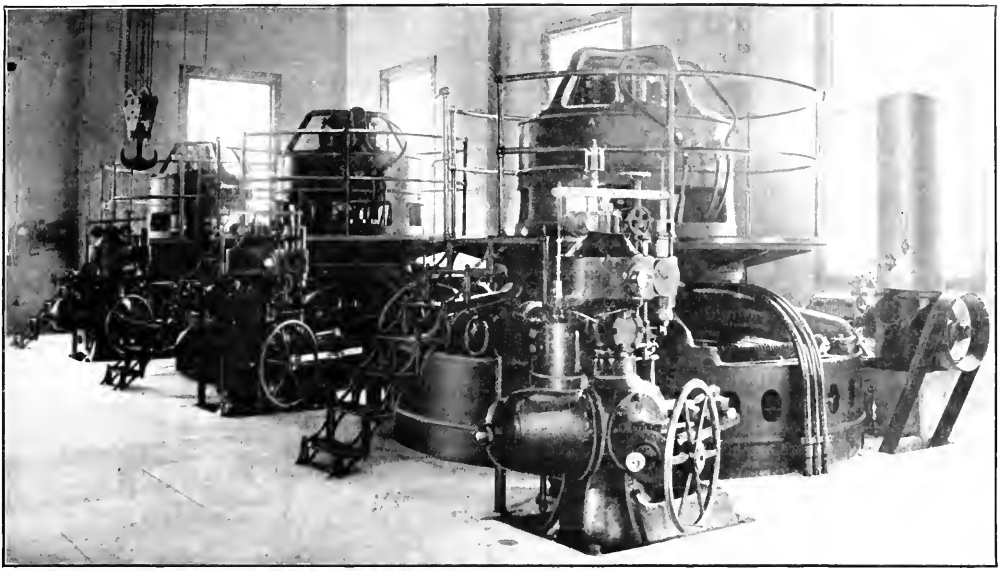

FIG. 2. GENERATING UNITS OF THE BOISE RIVER POWER PLANT

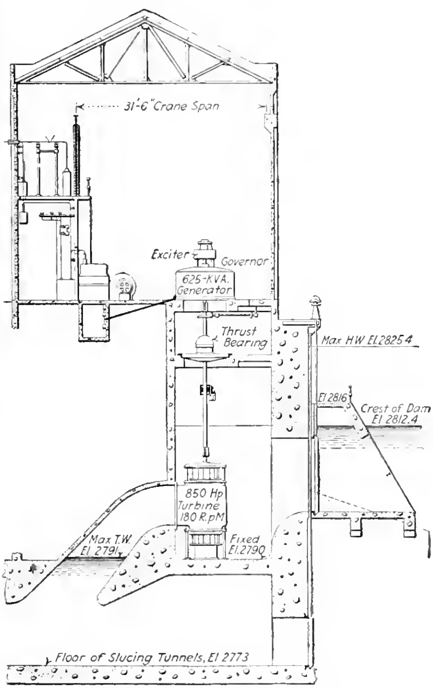

FIG. 3. ELEVATION OF ONE OF THE TURBO-GENERATOR SETS

The transformers for the alternators are air cooled by motor-driven blowers. An air compressor having a capacity of 50 cu.ft. per min. is provided for the needs of the station, and is driven by a 220-volt induction motor.

The present capacity of the plant is 1500 kw. A certain amount of electricity is used for local purposes on the dam, and some is used by the surrounding community, but the greater amount is intended and used for the building of the dam some fifteen miles distant. Nevertheless, the plant is a permanent structure and it is proposed to turn

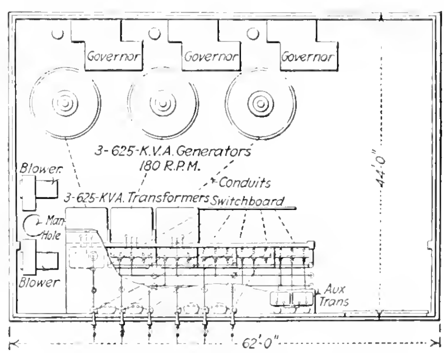

FIG. 1. PLAN OF THE BOISE POWER PLANT

the power over to local uses when the Arrow Rock dam is finished.

The plant is compact, the size of the power house being about sixty by forty feet. The irrigation canals which the dams in the project supply with water are in all about four hundred miles in aggregate length. The laterals from them are in the aggregate one thousand miles, an indication that the project is of more than ordinary consequence and magnitude.

Steam-Turbine Diagrams

By F. R. Low

SYNOPSIS—An explanation, "written so you can understand it," of the diagrams which show the working of the steam in turbine blades and how the energy of the swiftly moving jet is absorbed and converted.

To one riding in a railway car a ball traveling along parallel to the track, as in the line *mn*, Fig. 1, and with the same velocity as the car would appear to be stationary relatively to the car, just as though it were attached thereto by an invisible rod. If the car slowed up, the ball, although preserving its own velocity, would appear to shoot ahead, while if the car speeded up the ball would appear to be moving backward, with a velocity in either case equal to the difference between its own speed and that of the car.

FIG. 2

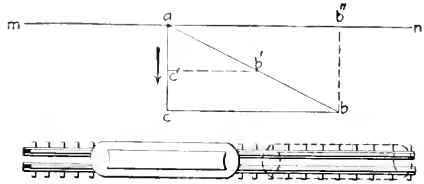

FIG. 1

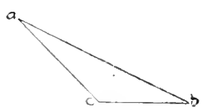

FIG. 3

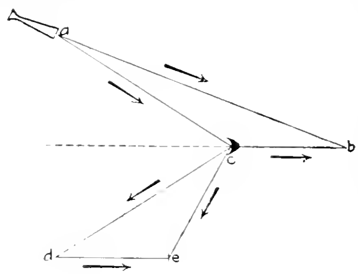

FIG. 4

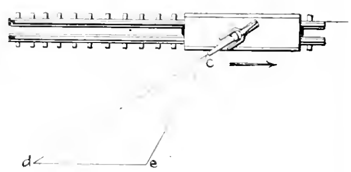

FIG. 5

Let the line *ab*, Fig. 2, represent in length and direction the velocity and direction of the ball. Set off upon it a distance *cb* representing to the same scale the velocity of the car at any instant. Then *ac*, the difference of these velocities, will be proportional to the speed of the ball relatively to the car; that is, to the velocity with which it would appear to the man in the car to be moving. Suppose the velocity of the car to be increased to that represented by the line *db*; then to the man in the car the ball would appear to be moving backward with a velocity proportional to *da*.

Returning to Fig. 1, suppose something should give the ball an impulse in the direction *ac*, with a velocity proportional to the length of that line, the velocity of the car and the previous velocity of the ball in the direction *mn* being proportional to $ab'' = cb$. To the man in the car the ball would appear to be coming straight toward him, just as though the car were standing still and the ball were batted from rest. And it would be coming straight toward him, for its motion relatively to the car would be in the line *ac*; but as the ball is going forward at the same time that it is moving sidewise toward the car, its path relatively to the ground would be *ab*, just as though it had gone to b'' first with its original velocity and direction, and then from b'' to *b*; but the car has gone ahead at the same time, so that it would hit it in the same spot and with the same velocity and at the same right angle as though both car and ball were standing still when the ball was impelled in the direction *ac*. At the end of the first half-second the ball, if moving only in the direction *ac*, would have gone from *a* to c', one-half of *a* to *c*, but in the same time, on account of its movement in the direction parallel to the track, would have gone from c' to b', so that at the end of the half-second it would be found at b'; and so for any subdivision of the time it would be found upon the line *ab*, which is the path that it would follow relatively to the ground.

If we represent, then, by the line *ab* the velocity and direction of the ball relatively to the ground, and by the line *cb* the direction and velocity of the car, the line *ac* joining their extremities will represent in length and direction the velocity and direction with and in which the ball approaches the car and with and from which it would appear to the man in the car to be coming.

With the ball still moving in the line *ab* and with a velocity proportional to the length of that line, suppose the velocity of the car to be reduced to *cb*, Fig. 3. Then the ball, although moving in the same direction and with the same speed relatively to the ground as before, will appear to the man in the car to be coming at him in the direction *ac*, Fig. 3, and with a velocity proportional to the length of that line.

Applying this to the relative motion of steam in a turbine, let *ab*, Fig. 4, represent, by its direction and length, the direction and velocity of a jet of steam issuing from a nozzle. Let *cb* represent the direction and velocity in and with which the blade moves. Then the jet would approach the blade in the direction *ac* and impinge upon it with a velocity proportional to the length of that line.

If the blade were symmetrical, so as to turn the jet back at the same angle, the jet would leave the blade in the direction *cd* and—neglecting loss from friction, impact, etc.—with the same velocity, *cd* = *ac*.

Suppose a ball to be fired from a gun placed at an angle upon a car, as in Fig. 5. If the car were standing still

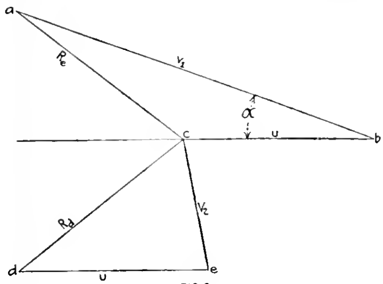

FIG.6

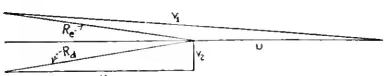

FIG.7

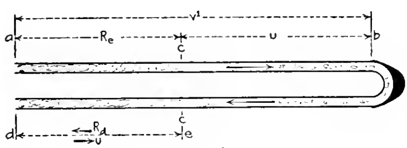

FIG.8

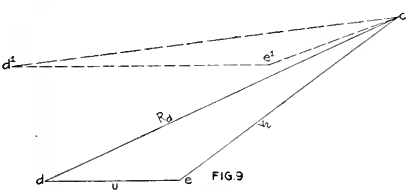

FIG.9

the ball would go off in the line *cd* relatively to the ground, but if the car were moving with a velocity which was to that with which the ball is projected as *de* is to *cd*, the ball would, by reason of the velocity acquired as a part of the car's contents, move forward a distance proportional to *de* in the same time that it moved the distance *cd* in the direction of its projection. Instead of being at *d*, therefore, it would be at *e*, and the path that it would have followed relatively to the ground would be *ce*.

In Fig. 4 we have a similar case. The steam is coming out from the blade in the direction and with the velocity *cd*, but it is traveling with the blade with the velocity and in the direction *cb* = *de*. Set off *de*, equal in length and parallel to *cb*, and the line *ce* will represent the direction and velocity of the steam when it leaves the blade with respect to the ground or to the stationary nozzle.

Fig. 4 or 6 is the typical diagram for a single-stage impulse turbine. The initial velocity is V_1 and the final velocity, V_2. The smaller V_2 in relation to V_1, the greater the proportion of the energy of the jet which has been absorbed by the turbine.

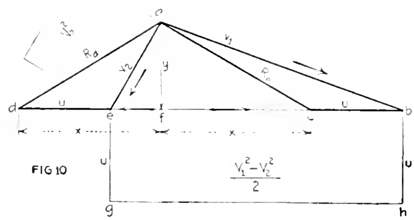

FIG 10

So long as the jet approaches the blade at an angle, as at *a*, there will be some sidewise direction to the final velocity V_2. As the angle *a* becomes less, the smaller may V_2 become, as in Fig. 7, until the jet is in line with the blade, Fig. 8, when the sidewise component disappears altogether and the diagram becomes a straight line, as shown in that figure. Its full length, $ab = V_1$, represents

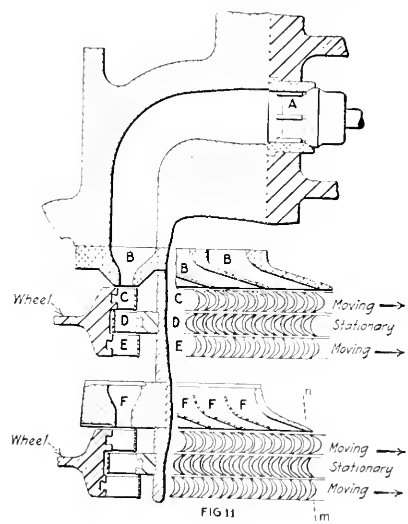

FIG 11

the initial velocity; *cb* = *u*, the blade velocity, and *ac* = R_e, the relative velocity and direction of entry, just as it did in the preceding figure, only that the triangle has been closed up and *c* lies upon the line *ab*.

If the jet is going at, say 1000 ft. per sec., and the blade is running away from it at 500 ft. per sec., the jet will be overtaking the blade at the rate (that is approaching it with the relative velocity) of 1000 — 500, or $R_e = V_1 - u = ab - cb = 500$ ft. per sec. This is R_e, the relative velocity with which the jet enters the blade. Neglecting friction, the jet is reversed in the blade and thrown backward to the same velocity R_d relatively to the blade; but, like the ball that was fired backward from the car in Fig. 4, it must have its forward motion subtracted from its backward velocity to show its velocity relatively to the ground. And when, from the relative velocity of discharge R_d, Fig. 8, we subtract the blade velocity u, by setting off upon the line $dc = R_d$ the line $de = u$, we have nothing left, indicating that velocity and energy have all been abstracted, that the steam has been brought completely to rest.

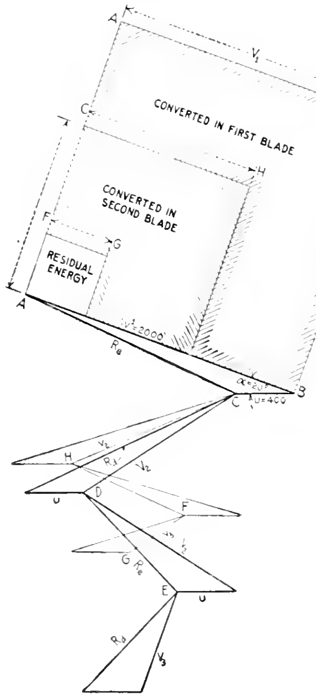

FIG 12

In order to do this for the abstract case the blade velocity u must be one-half the initial absolute velocity V_1, Fig. 7; for in order that the blade velocity $u = de$, Fig. 8, may equal and cancel the relative discharge velocity $R_d = cd$, u must also equal R_e, to which R_d is also equal; and since ab equals $R_e + u$, each of these quantities, if they are equal, must be one-half of ab.

Fig. 9 is the typical diagram for a single stage of a reaction turbine; $cd = R_d$ represents the direction and velocity with which the steam is discharged from the blade; u is the blade velocity, and V_2 the velocity relatively to the ground, as in the other diagram. So long as the jet is delivered at an angle there will be some residual velocity V_2 in the jet. By reducing the angle and increasing the blade speed, as shown in the dotted position, this residual velocity could be reduced from ec to $e'c$, but it is only when de becomes parallel with and equal in length to dc that the residual velocity disappears altogether. The blade of a reaction turbine must run at the same velocity as the jet, in order to reduce its velocity to zero and extract all of its energy. If a car were paying out a cable slower than the car was running, it would be dragging the cable along the ground. If it were paying the cable out faster than the car was running, it would be pushing the cable backward. If the speed of the cable through the opening in the car equaled the forward movement of the car, the cable would be laid quietly upon the ground with all the velocity and momentum which it possessed, as a part of the car's contents, taken out of it.

In Fig. 10 the triangle $cdec$ has been moved from the position which it occupies in Figs. 4 and 6 and attached to the other triangle at a instead of at c, producing the diagram which, as shown in the firmer lines, is frequently seen in turbine literature. The jet travels a distance proportional to ab in a second, in the direction in which it is discharged, but moves only a distance proportional to fb in the direction db in which the blade is moving.

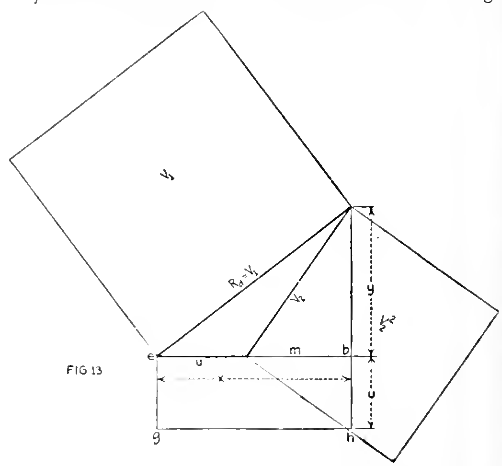

FIG 13

This line fb (the length of which is determined by dropping upon it a perpendicular as af from the other extremity of the line to one extremity of which it is connected) represents the "component" in the direction db of the velocity represented by ab. This component of the entering velocity is fb; the component of the discharge velocity ae is ef, opposite in direction from fb. The blade, therefore, has overcome, or annulled, the velocity fb and has gotten up new velocity fe. In other words, it has retarded the steam enough to destroy the velocity fb and accelerated it enough to produce the velocity fe. But retardation is only negative acceleration, and the effect is the same as though the steam had been accelerated from rest to a velocity proportional to be.

The *force* which must be exerted upon a body to produce a change in the velocity of its motion is equal to the product of its mass and the acceleration produced.

The *energy* is equal to the product of the force and the space through which it is exerted.

The energy produced by the flowing through the blades of a given mass of steam per second will be

$$\textit{Energy} = \underbrace{\textit{mass} \times \textit{acceleration}}_{(force)} \times \underbrace{\textit{blade speed}}_{(space)}$$

The acceleration is *be* and the blade speed u, equal to *bh* or *eg*, so that the area of the rectangle *ebhge* equals the product of the acceleration and blade speed, and the energy absorbed by the blade equals *mass* $\times$ area *ebhge;* that is, is directly proportional to that area.

The energy stored in a moving body is the product of the mass and one-half the square of its velocity. The energy in the entering steam is proportional to *mass* $\times \frac{V_1^2}{2}$, or to the area of the square upon the line *ab* multiplied by one-half of the mass. The residual energy in the escaping steam is *mass* $\times \frac{V_2^2}{2}$, or the area of the square erected upon the line *ae* multiplied by one-half the mass. The difference, *mass* $\times \frac{V_1^2 - V_2^2}{2}$, represents the difference in the energy of the steam as it enters and leaves the blade. But, neglecting friction, etc., there is no other place for the energy to go than to be absorbed by the blade, and the difference ought to be equal to the energy which we found to be so absorbed; hence

$$Mass \times \frac{V_1^2 - V_2^2}{2} = mass \times ebhge$$

Or, since the mass is common to both,

$$ebhge = \frac{V_1^2 - V_2^2}{2}$$

That is, the area *ebhge* equals one-half of the difference between the areas of two squares on *ab* and *ae*, or the difference between the areas of the two squares is twice the area *ebhge*.* Notice also in passing, that the work done is directly proportional to the line *eb;* that is, to the force exerted in the direction of the blade movement.

The velocity-stage turbine abstracts a portion of the residual energy V_2 by passing the steam again through the same or another set of blades. Suppose the size and speed of the turbine were such that a blade velocity u of 400 ft. per sec. could be obtained. Suppose, further, that the conditions as to initial pressure, superheat and vacuum were such that the steam would attain a velocity of 4000 ft. per sec. if allowed to complete the expansion in a single stage.

If the turbine were designed so that the steam would acquire half this velocity in the first stage, there would have to be three more such stages to complete the expansion; that is, if the work were to be equally divided between the stages, or if in no stage was the velocity to exceed 2000 ft. per sec., it would have to be a 4-stage turbine. The energy in a moving body varies as the *square* of the velocity. There is only one-quarter as much energy in steam flowing at 2000 ft. per sec. as at twice that speed, so that three similar stages with velocities of 2000 ft. would have to be used to take out the other three-quarters.

The velocity decreases inversely as the square root of the number of stages—½ the velocity for 4 stages, ⅓ the velocity for 9 stages etc.

Suppose, then, the steam is expanded in the first stage through a range that will give it a velocity of 2000 ft. per sec. The blade speed is 400 ft. per sec. and the angle a of the nozzle 20 deg., as shown in Fig. 11. It will be seen that there is considerable residual velocity V_2. The only way to reduce this would be to reduce the initial velocity V_1, which, as just shown, would require a number of stages varying as the square of the number of times the velocity is reduced, or to increase the blade speed u, which by the conditions of the case is impossible.

The somewhat common impression that reducing the blade speed and employing more stages produces better economy is not borne out by this analysis. For the abstract case the hydraulic efficiency depends upon the ratio of the steam speed to the blade speed and would be the same for one-half the blade speed if the steam speed were also halved. The turbine built with the greater number of stages would, however, be the more efficient because of the reduced surface friction, and because of the greater area of blade passage due to the lower velocity. The nozzles would occupy a greater number of degrees of the wheel surface and the gain from reheating would be slightly greater.

Fig. 11 shows diagrammatically a Curtis turbine. The high-pressure steam enters at A and expands in the nozzles BBB, impacting upon the moving blades CC, which are carried upon the crown of the running wheel, as shown at the left. Carried upon the casing is a set of stationary blades DD into which the steam is discharged with the velocity and in the direction R_d (of the diagrams), and in which the steam is turned around and discharged upon the blades E, also attached to the moving wheel. The blades E are deeper than the first ones C, not because the steam is supposed to expand in going through them, but to allow the constant volume of steam to pass at a decreased velocity. It comes off from the last row of blades E at the same pressure as that with which it left the nozzle B, but with its velocity very much reduced, and passes to the second set of nozzles FFF to have its velocity accelerated by another expansion.

If the blades were symmetrical the diagram for the abstract case would be that shown by the heavy lines in Fig. 12. The velocity V_2 with which the steam leaves the blade C is the same with which it enters the stationary blade D and with which it is discharged in the reverse direction upon the blade E, but the angle of this line is no longer 20 deg., and that of the relative entry R_e (see line DE, Fig. 12) approaches the bucket at much too broad an angle. The buckets are, therefore, so fashioned as to send the steam off at a sharper angle than that at which they receive it. Notice that a line drawn across the tips of a blade, as *mn*, Fig. 11, is not square with the line of the blade's movement. This results in a diagram more like that shown by the lighter lines in Fig. 12.

The final residual velocity V_3 is reduced to that indicated by the line FG. The initial energy is proportional to the area of the square on V_1, the energy of the steam as it enters the second rotating blade by the middle square, the difference being proportional to the energy taken out in the first blade. The residual energy is proportional to the smallest square and the energy taken out by the second blade to the difference between the areas of this and the middle square. The side of the second square is the V_2 and of the smallest square the V_3 of the lighter diagram. Unsymmetrical buckets on the moving wheel result in end thrust and must be used with discretion.

The reaction of a jet, or the force with which it pushes the nozzle backward, is *mass* $\times$ *velocity*. The absolute ve-

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*$V_1^2 = (x + u)^2 + y_2 = x^2 + 2xu + u^2 + y^3$
$V_2^2 = (x - u)^2 + y^2 = x^2 - 2xu + u^2 + y^3$
Subtracting the two equations
$V_1^2 - V_2^2 = 4xu$
Hence $\frac{V_1^2 - V_2^2}{2} = 2xu = 2x \times u$, which is the area ebhge, for eb = dc = 2 x.

locity with which the jet leaves the blade is R_d in Fig. 13; the component of this velocity in the direction of the blade movement is $x = u + m$. The energy absorbed per second is the product of this force by the space moved through in a second, that is, by the blade velocity. It is, therefore, proportional to $mass \times u \times (u + m) = mass \times (u^2 + um)$. The energy due to the issuing velocity is $mass \times \frac{V_1^2}{2}$, that due to the residual velocity $mass \times \frac{V_2^2}{2}$, and the difference $mass \times \left(\frac{V_1^2 - V_2^2}{2}\right)$.

Leaving off the mass, which is common to both, it would seem that, as in the case of Fig. 10, the rectangle $ebhge = u^2 + um$, representing the energy absorbed, ought to be equal to one-half the difference of the two squares representing to the same scale the initial and final energies. But the difference in the two squares is easily proven to be $u^2 + 2\,um$.* Twice the rectangle would be $2\,u^2 + 2\,um$. The difference in the squares is less than twice the rectangle by just u^2; that is, by just the square of the blade velocity. This is because there was in the steam not only the energy due to the velocity with which it issued from the jet, but the energy which it took to get it into the blade and moving with the blade's velocity. If a diagram similar to Fig. 10 be drawn with the line $ac = R_e$ at right angles to the movement of the blade, it will represent the action of a pure reaction turbine, and the additional energy will be found in the motion represented in the line ab of such diagram.

Staying a Furnace Arch

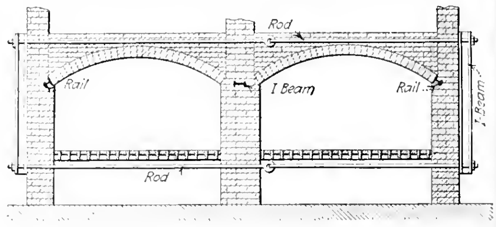
By J. C. Hawkins

Nearly every type of modern boiler furnace recommended to assist in giving complete combustion and to prevent smoke consists of firebrick piers, baffle walls, etc., placed directly in the path of the gases to cause a better mixture of the air and combustibles.

These gases are at a high temperature and impinge on the baffles and piers, often causing the firebrick to melt down quickly. The writer has seen bridge-walls in standard horizontal water-tube boiler settings, in which the top of the wall was melted and had run down on the back like huge icicles. The same trouble, only of a more serious nature, may occur in the arch of a dutch-oven furnace. If the arch is wide it exerts considerable pressure on the side walls and when the bricks become hot they tend to crush, the wall settles and exerts a greater pressure on the side walls. If the walls are not well stayed they will be pushed out and much air may leak in where it is not wanted.

The writer had considerable trouble of this kind in a battery of two vertical water-tube boilers with dutch-oven furnaces. The grate was 84 in. wide in each boiler and each furnace had a single-span arch. Each time the arch was renewed, which was about once a year, it pushed the walls farther out, and it was necessary to put in additional tie-rods. The accompanying sketch shows how this was accomplished. Four rods, 1¼ in. diameter each, were used; one was set at the end of the arch and one just inside the front wall. The lower rods were put in below the grate and close to it so as to be out of the way and not interfere with the pulling of the ashes. The top rods were covered with firebrick and ashes to protect them from the heat. The rods were made long enough to pass through the two settings, with a long thread and nut on each end. On account of close quarters the rods had to be linked in the center to get them in place. Four pieces of old railroad rail, each about 6 ft. long, were used as buckstays. In addition to these rods a 5-in. railroad rail about 8 ft. long was embedded in the center wall and also in the outside walls at the point where the arch rested, to strengthen the wall at this point.

This arch was constructed of a special grade of furnace brick and would last about a year, with hard firing. It is not usually possible to patch this arch when the center burns out, as it is generally sprung out of shape and sagged in the center. It is left as long as it will stand,



How the Furnace Arches Were Stayed

then torn out and a new one built. In the parts of the lining where the brick is not subjected to the extreme heat common firebrick will be found satisfactory and cheaper than the high-grade brick used in the furnace. After the bricks become glazed over, which protects them, they should not be disturbed until it is necessary to repair them.

Fluid Cling-Surface

To overcome the necessity of heating Cling-Surface belt dressing without impairing its efficiency has long been the aim of the Cling-Surface Co., Buffalo, N. Y.

This has been accomplished, and the dressing has been converted to a semifluid ready for use at any temperature above 60 deg. F. In other words, no heating is required during eight to ten months of the year, nor in the winter if it is kept in a warm room. Where it is kept in a cold room or exposed to winter temperature, it need not be heated above 100 deg. F., and then only for a few minutes for softening.

U. S. Coal Production in 1914—According to Edward W. Parker, statistician of the United States Geological Survey, the total coal production of the United States in 1914 was about 510,000,000 short tons, a decrease of about 60,000,000 tons compared with the record output of 1913. Practically all of this decrease was in the output of the bituminous mines. The production of Pennsylvania anthracite in 1914 was not materially different from that of the preceding year, which was 81,718,680 long tons. In 1914, however, about 1,000,000 tons (principally nut and steam sizes) went into storage, so that the quantity sent to market was about 1,000,000 tons less than in 1913. The principal decreases in the production of bituminous coal were in the coking districts. It is estimated that in Pennsylvania alone the production of bituminous coal decreased between 20,000,000 and 25,000,000 tons, and that the larger part of this decrease was in Fayette and Westmoreland counties, which constitute the Connellsville and Lower Connellsville coking districts.

$$\begin{aligned} {}^*V_1^2 &= y^2 + (u+m)^2 = y^2 + u^2 + 2\,um + m^2 \\ V_2^2 &= y^2 + m^2 \\ \text{difference} &= u^2 + 2\,um \end{aligned}$$

Interior Wiring for Lighting and Power Service—I

By A. L. Cook*

SYNOPSIS—The first of a series of articles covering the methods employed in making plans of lighting and power systems for industrial establishments and office buildings, and in calculating the sizes of wires required for such service. The treatment is such as to meet the requirements of superintendents or engineers in charge of such buildings, who may be called upon to make additions to or changes in the equipment; and no attempt has been made to cover problems which should be handled by the illuminating engineer or a power specialist. The first installment covers the voltages and systems employed, the National Electric Code Rules, the types, number and spacing of lamps and the determination of the lighting load.

The usual voltages employed for lighting are about 120 or 240 with a two-wire system and 120 for each side with a three-wire system. Either direct or alternating current may be used. Occasionally, three-phase or two-phase alternating current is employed for lighting, because of peculiarities in the conditions of supply. For alternating-current lighting 60 cycles is generally used, since 25 cycles is not as satisfactory owing to a flickering of the lights in some cases. It has been found, however, that tungsten lamps having a rating of 60 watts or more can be employed satisfactorily on 25 cycles. With ordinary inclosed arc lamps, 25 cycles is not satisfactory, although flame-carbon arc lamps can be used on this frequency. For direct-current motors, the standard voltages are 115, 230 or 550, and for alternating-current motors, 110, 220, 440 and 550 volts are commonly employed, although in some cases for very large motors, 2200 volts is used. The frequency may be either 60 or 25 cycles, and occasionally 40.

The voltages given for lighting and power service are the values at the lamps or motors. The standard generator voltages for direct current are 125, 250 and 600, and for alternating current, 120, 240, 480 and 600, which allows a reasonable drop between the generator and the load. In some cases a multivoltage system is used for motors, in order to give a ready means of varying the speed. This is not generally necessary, however, since modern direct-current motors permit wide speed variation by a change in the field strength.

The choice of a particular system for lighting or power service is affected by a number of factors, such as the character of the existing system or the central-station source of supply, and the relative sizes of the power and lighting loads. When an extension is to be made to an existing installation, the same system must be used for the extension, unless the addition is so large or the requirements differ so widely that a change in the system or the addition of a different kind of supply can be seriously considered. For a new plant more freedom of choice exists, and the relative merits of the various systems will therefore be considered.

Direct vs. Alternating Current

For lighting, either alternating or direct current would, in general, be satisfactory, and the advantage of easy change of voltage in the case of the former makes it preferable in supplying buildings covering large areas. However, the lighting load is usually small, compared with the power load; hence the choice is fixed by the power requirements. The important advantages and disadvantages of alternating and direct current for power supply may be summarized as follows:

DIRECT CURRENT	ALTERNATING CURRENT
It is not generally feasible to use more than 240 volts for lighting. Therefore this limits the voltage of the system if supplied from the same generator as the motors.	The voltage can be easily transformed, using voltages suitable for lights and motors.
2. Maintenance is higher, owing to commutators.	2. There is no commutator; hence the motor is more rugged. It will stand larger momentary overloads, there is no danger of fire from sparks at the commutator and it is more reliable.
3. Wide speed variation of motor by simple means, with high efficiency.	3. Speed variation is difficult and the motor is less efficient at reduced speeds.
4. Motors have better starting characteristics for cranes and elevators.	4. Operation is not satisfactory on high-speed elevators and large cranes. Starting current is greater.
5. Starting current is lower for usual types of constant-speed motors.	5. Starting current for ordinary type is large. Special arrangements are necessary to reduce it.
	6. A somewhat larger generator is required for a given motor load.

The relative sizes of the power and lighting loads will have an important bearing upon the selection of the system. In some cases of light manufacturing, particularly if all the work is in one building, where the feeders would be short, direct current might well be used, employing 120 volts two-wire for small systems, and 240 volts three-wire, or possibly two-wire, for larger systems. If a two-wire system be used, the feeders would be about one-fourth as large for the 240 volts as for 120 volts; but, on the other hand, the lighting would have to be supplied at 240, which would entail somewhat greater cost for lamps and maintenance. It is better to operate the motors at 240 volts and supply the lights on a 120-240-volt three-wire system. By this means, the saving in size of feeders is nearly as great as if the entire load were supplied at 240 volts and the advantage of the lower-voltage lamps is secured. The additional power-house equipment is of small cost.

For most industrial uses, the alternating-current motor is satisfactory, and in some cases almost necessary, either because of the great distances from the power house or the

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severe operating conditions due to dust, moisture, etc. Its principal disadvantage is the difficulty in adjusting the speed. With a direct-current system it is possible to obtain motors which will allow a speed change of three to one. When the speed is adjusted to a given value between these limits, it will remain practically constant regardless of the load. Such motors are extensively used for driving lathes and similar machine tools. It is possible to provide means by which the speed of an alternating-current motor can be adjusted to as wide a range as the direct-current motor, but usually at a sacrifice in efficiency; whereas, the direct-current motor has nearly the same efficiency at all speeds. Moreover, the variable-speed alternating-current motor, having been adjusted to a particular speed, will not maintain this as the load changes; instead, the speed will increase as the load decreases. This wide speed variation is objectionable where constant speed with varying load is necessary, as in machine-tool driving; but for some purposes, such as ventilating fans, centrifugal pumps, paper machines, and the like, where the load does not vary suddenly, the use of an alternating-current adjustable-speed motor is satisfactory. Alternating-current motors are not as satisfactory for cranes and elevators, owing principally to the difficulty of control, particularly when making stops. For this reason direct-current motors are to be preferred for high-speed elevators and large cranes. Therefore, in an office building where the elevator load is usually greater than the other motor load and the length of the feeders is not great, the direct-current system is preferable. For large buildings the three-wire, 240-volt system should be used, the motors operating at 240 volts and the lights at 120. Only in small buildings should the 120-volt two-wire system be used.

If the building is not supplied from a power plant on the premises, but obtains its supply from a central station, the type of service will depend upon the system of the supply company. If only alternating current is available it will be best to use alternating-current elevators unless the speed is high (above 300 ft. per min.) rather than provide the necessary transforming apparatus. For industrial establishments in general, the alternating current is to be preferred unless the cranes and variable-speed tools form a large proportion of the total load. If it is absolutely necessary to use direct current for some of the motors, it is better to provide alternating-current service for general uses, with a direct-current supply for cranes and special work.

When installing any wiring it is desirable to conform in all respects to the local rules governing such installations. The rules of the National Board of Fire Underwriters, called the "National Electric Code," form the basis of most of the regulations which have been issued by various cities and other parties interested, and must be followed in order to obtain fire insurance on property. These rules may be obtained gratis from the National Board of Fire Underwriters by applying to its New York, Boston or Chicago offices. The Inspection Department of the Associated Factory Mutual Fire Insurance Companies, with an office in Boston, has issued the "National Electric Code" with explanatory notes, thus giving in many cases more specific directions for the proper installation of electrical apparatus than is contained in the "Code." In many cases there are rules issued by the city inspection departments, which are substantially the same as the "National Electric Code," but care should be taken to see that the work not only meets the code requirements but also conforms to the local rules. In the following discussion the rules of the "National Electric Code" are followed.

Choice and Distribution of Lamps

The subject of the proper illumination of industrial establishments has in the past few years been given considerable attention on the part of factory superintendents and managers, who have begun to realize that it pays to provide sufficient illumination. Investigations have shown that an efficient lighting system increases the output from 2 to 10 per cent., and it has also been found that the number of accidents is materially reduced when adequate lighting is provided.

For interior illumination of buildings, there are available the following types of lamps:

Lamp	Service
1. Carbon-filament	A.C. or D.C.
2. Gem- or metallized-filament	A.C. or D.C.
3. Tantalum	A.C. or D.C.
4. Tungsten, including "nitrogen" filled lamps	A.C. or D.C.
5. Inclosed-carbon arc	A.C. or D.C.
6. Metallic-flame or magnetite arc	D.C.
7. Flame-carbon arc	A C. or D.C.
8. Nernst	A.C. or D.C.
9. Cooper-Hewitt mercury arc	A.C. or D.C.

While all of the foregoing types have been used for interior illumination, the practice has now become so standardized as to make the tungsten lamp by far the most common for ordinary heights of ceilings. The metallic-flame arc and flame-carbon arc are used for lighting large floor areas with high ceilings, particularly where there is more or less smoke and gas. The so-called nitrogen-filled lamp, which is a special form of tungsten lamp with the bulb filled with nitrogen or a similar gas, is very useful where large lighting units can be employed, and the tendency is to use this in place of the metallic-flame or flame-carbon arc, owing to the reduced cost of maintenance. The mercury arc has also been used extensively, principally because of its small power consumption, but it produces such an objectionable color that it is unsuitable for many uses and can better be replaced by the nitrogen-filled lamp. This gives a light even whiter than the ordinary tungsten lamp with a power consumption not much greater than that of the mercury arc. Present practice, therefore, for rooms of ordinary height, has narrowed down to the use of tungsten lamps with glass or steel reflectors, mounted near the ceiling and arranged to give sufficient illumination to the entire room. In general, drop cords with individual lights have been eliminated as far as possible and are used only for special work which cannot be lighted from the overhead lamps. Where it is necessary to use individual lights, a 16-cp. carbon-filament or a 40-watt gem lamp is used. The latter is preferable as it gives the same candlepower as the carbon and requires about 20 per cent. less power. Table 1 gives data on the various sizes of tungsten lamps.

TABLE 1—DATA ON TUNGSTEN LAMPS*

Size, Rated Watts	Candle-power	Watts per Candle-power	Life, Hours	Approximate Current, Amperes 120 Volts	240 Volts
25	24	1.05	1000	0 21	0.11
40	39	1.03	1000	0.33	0.17
60	60	1.00	1000	0.50	0.25
100	105	0 95	1000	0.83	0.42
150	167	0.90	1000	1.25	0.62
250	278	0.90	1000	2.08	1.04
400	445	0.90	1000	3.33	1.67
500	555	0.90	1000	4.16	2.08
†200	222	0.90	1000	1.67	...
†300	353	0.85	1000	2.50	...
†400	534	0.75	1000	3.33	...
†500	714	0.70	1000	4.16	...
†750	1150	0.65	1000	6.25	...
†1000	1665	0.60	1000	8.33	...

*From figures supplied by the National Lamp Works of the General Electric Co. The above applies to 120-volt lamps; for 240-volt lamps the watts per candlepower are about 10 per cent. higher.

†Nitrogen-filled lamps of 120 volts only.

Sizes smaller than 25 watts are manufactured, but are not suitable for industrial lighting. For multiple inclosed-flame arcs the following values are typical:

	Direct Current	Alternating Current
Voltage	110	110
Watts	715	510
Amperes	6.5	7.5
Power factor		0.62
Candlepower	1740	1600
Watts per candlepower	0.41	0.32

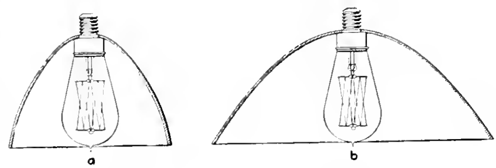
In the case of the arc lamp, the candlepower refers to the average for the lower hemisphere of the lamp. For the tungsten lamps the candlepower and efficiency values are based on average candlepower in a horizontal direction when the lamp is vertical, no reflectors or shades being used.

It is not the intention to go into the details involved in the determination of the proper number and spacing of lamps for all classes of service, as this is a task for the illuminating engineer. Careful calculations of such a problem require considerable experience and a knowledge of the effect of reflection from walls and ceilings. It is frequently necessary, however, to make a rough estimate of the amount of power required for lighting, in order to provide the necessary feeder and generator capacity. There are a few simple rules that can be applied in such cases, which will give satisfactory results under usual conditions.

It is first necessary to determine the amount of power required for a given floor area. This will depend, of course, upon the amount of light necessary, which will vary with the character of the work carried on. Table 2 gives the number of watts required per square foot of floor area for different classes of work, with various arrangements of tungsten lamps. These values are based on good practice and will give first-class illumination under average conditions. The principal item which would affect these values is the color of the ceilings and walls. For offices, stores, corridors and drafting rooms it is assumed that both the ceilings and the walls are fairly light in color, while for factories, warehouses and power houses they would be darker and less light would be reflected. The figures given for general office illumination are sufficient for usual office work, while those for special illumination should be used where bookkeeping or work of a similar nature is carried on. The amount of power allowed for a drafting room is sufficient to provide suitable illumination without the use of individual lamps. For rooms where rough manufacturing is carried on and where close application to the work is not required, the figures for general factory illumination should be sufficient; for fine machine work, toolmaking and bench work, those for special factory illumination should be used. The lamps should be provided with suitable reflectors, in order to direct as much of the light as possible on the work. There is a great variety of these reflectors, but they can all be grouped in a few general classes, each of which is best adapted for particular conditions. There are on the market several types of glass reflectors which direct most of the light in a downward direction, but allow a certain amount to pass through to the ceiling. The best example of this type is the prismatic "Holophane." In order to have a good distribution of light, it is necessary to employ the proper style of reflector; hence a different size is manufactured for each size of tungsten lamp. It is necessary also to use the right type of shade holder in order that the lamp may be correctly located in the reflector.

Since modern systems of illumination are usually laid out to give practically uniform lighting over the entire floor area, it is necessary to use different types of reflectors for different heights of ceilings and spacings between lamps. The Holophane prismatic glass reflectors are made in three styles: "Extensive," for low ceilings; "intensive," for medium ceilings; and "focusing," for high ceilings. Glass reflectors are best adapted for offices, stores, drafting rooms and similar places, where it is desirable to light the walls and ceilings, as well as the work. They have also been used quite extensively for factory lighting, but are not suitable for use where there is danger of breakage.

Steel reflectors are made in a number of styles, with white porcelain-enamel surfaces, white painted surfaces, or aluminum painted surfaces. In general, the porcelain-enameled reflector is better than the others, owing to a great reflecting power, and the ease with which it can be kept clean. There are two general types of steel reflectors—the bowl, shown in Fig. 1-*a*, and the dome, in Fig. 1-*b*. These reflectors are made in various sizes to suit particular tungsten lamps, and in various shapes for different heights of ceiling. The dome type (*b*) should be used generally; the bowl type (*a*), which incloses the lamp more than the dome, being used only when the lamps are mounted so low that they would be in the line of sight of the workmen. When steel reflectors are used, the ceilings are not illuminated, except by a small amount due to reflection from the benches or tables; but for many industrial applications this is not objectionable. In offices the steel reflectors do not give a pleasing effect. Values for either glass or steel reflectors are given in column A of Table 2, since they are both classed as direct illuminants. For the same character of walls and ceilings there would be only a slight difference in the amount of illumination produced by the two types.



a b

FIG. 1. BOWL TYPE DOME TYPE

TABLE 2—POWER REQUIRED FOR ILLUMINATION. TUNGSTEN LAMPS*

Class of Work	Watts per Square Foot Direct A	Indirect B
Office—general	1.00	1.60
Office—special	1.25	2.00
Drafting room	2.00	3.20
Corridors and halls	0.50	0.80
Factories—general	0.80	...
Factories—special	1.50	...
Warehouses	0.50	...
Stores	1.25	2.00
Power house	0.80	...
Storage	0.30	...

*If nitrogen-filled lamps are used, multiply the watts per square foot as given above by 0.75.

In some cases, particularly in drafting rooms, the indirect system of lighting is preferable. With this the light is directed upon the ceiling and is then reflected onto the work. It results in lower efficiency, but in many cases is justified, in order to eliminate troublesome shadows. A modification of this system involves the use of reflectors, which allow a small portion of the light to be directed downward, giving what is called a semi-indirect system. A satisfactory arrangement with this system is to employ glass reflectors mounted on suitable fixtures and pointed toward the ceiling, instead of downward, as is usual. The indirect system depends for its efficiency upon light-colored ceilings and walls, and therefore is better adapted for use in offices, stores and drafting rooms than in factories.

The allowable watts per square foot for a given class of work can be found from Table 2, and when multiplied by the floor area, will give the total power required. It may seem to some that the height of the lamp above the work would have a decided effect upon the amount of power required, but this is not the case provided a suitable reflector and proper spacing of the lamps are employed. There is, however, a considerable difference in lighting depending upon the number of units employed and the color of the walls and ceiling.

As an example, the figures of Table 2 will be applied to the lighting of four floors of a factory building having a width of 46 ft. and a length of 135 ft., divided into nine bays 15 ft. wide, with a line of columns down the center of the building. Table 3 gives a tabulation showing the lighting to be provided for each floor.

TABLE 3—EXAMPLE OF LIGHTING CALCULATION

Floor	Character of Work	Ceiling Height, Feet	Area, Sq.Ft.	Assumed Watts per Sq.Ft.	Size of Unit	Actual Watts per Sq.Ft.
Basement	—Storage	8	6210	0.30	60	0.35
First floor	—Machine shop	14	6210	1.50	100	1.74
Second floor	—Assembly...	12	6210	1.50	100	1.74
Third floor	—Stock room..	12	6210	0.50	100	0.58

This building would employ direct lighting by means of tungsten lamps, and steel or glass reflectors. From the

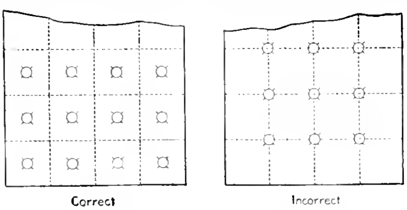


Fig. 2. Spacing of Ceiling Outlets

given floor areas and the allowable watts per square foot, the approximate amount of power can be estimated. This would be sufficient for an estimate of the total load required for the lighting, but in general it is best to choose the size of units and determine the number to be employed, since the spacing which must be used often modifies the total load.

The spacing and size of unit to be used are affected by the height of ceiling as well as by the arrangement of the beams or girders. There is a certain relation between the height of the lamps and their size, which must be adhered to as closely as possible, in order to get uniform illumination without objectionable shadows. For low ceilings the units should be small and closely spaced, while for high ceilings large units, more widely spaced, should be used. Table 4 will serve as a guide to the selection of the proper size of unit. This should be used in connection with Table 5, which gives the approximate spacing of lamps of different sizes.

The units should be mounted at least 8 ft. from the floor and more if possible; a height of 10 ft. being satisfactory for rooms with ceilings 11 to 16 ft. high. For higher ceilings, cranes and other obstructions usually fix the height of mounting. If deep girders divide the ceiling

TABLE 4—SIZES OF LIGHTING UNITS FOR VARIOUS MOUNTING HEIGHTS

Height of Unit above Floor	Size of Unit, Watts
Up to 9 ft................	40 or 60
9 to 11 ft................	60 or 100
11 to 16 ft................	100 or 150
16 to 20 ft................	150 or 250
20 ft. and above............	250, 400, 500 and nitrogen-filled lamps or flame arcs

TABLE 5—APPROXIMATE SPACING DISTANCES FOR LIGHTING UNITS

Size of Units, Watts	Watts per Sq.Ft., Direct*	Spacing Distance	Size of Units, Watts	Watts per Sq.Ft., Direct*	Spacing Distance
40	0.3	11 ft. 6 in.	150	1.5	10 ft.
40	0.5	9 ft.	150	2.0	8 ft. 8 in.
40	0.8	7 ft.			
			250	0.3	29 ft.
60	0.3	14 ft. 2 in.	250	0.5	22 ft. 5 in.
60	0.5	11 ft.	250	0.8	17 ft. 8 in.
60	0.8	8 ft. 8 in.	250	1.0	15 ft. 10 in.
60	1.0	7 ft. 9 in.	250	1.25	14 ft. 1 in.
60	1.25	7 ft.	250	1.5	12 ft. 11 in.
60	1.5	6 ft. 4 in.	250	2.0	11 ft. 2 in.
100	0.5	14 ft.	400	0.8	22 ft. 5 in.
100	0.8	11 ft. 2 in.	400	1.0	20 ft.
100	1.0	10 ft.	400	1.25	17 ft. 11 in.
100	1.25	9 ft.	400	1.50	16 ft. 4 in.
100	1.5	8 ft. 2 in.	400	2.0	14 ft. 1 in.
100	2.0	7 ft.			
			500	0.8	25 ft.
150	0.5	17 ft. 4 in.	500	1.0	22 ft. 5 in.
150	0.8	13 ft. 8 in.	500	1.25	20 ft.
150	1.0	12 ft. 3 in.	500	1.50	18 ft. 3 in.
150	1.25	11 ft.	500	2.0	15 ft. 10 in.

*The figures given apply to ordinary tungst lamps. In general the spacing of lamps should be about 50 per cent. greater than their height above the work illuminated.

into bays, the lamps should be located slightly below the bottom edge of the girders if possible. Having fixed upon a suitable mounting height, a size of unit should be chosen by reference to Table 4. The rating of this unit divided into the total watts for the given floor area will give the required number of lights. This number should then be laid out upon a plan of the room and the spacing checked with the average values given in Table 5. The lamps should be located without reference to the individual machines, so that a change in the latter would not affect the system. Each light should, if possible, be located in the center of a square, the length of the side being the spacing distance assumed. The lamps should be arranged in parallel rows, the distance between rows each way being as nearly as possible equal to the given spacing distance. The distance from the wall to the first row should be about one-half the spacing distance, except where benches are located at the side walls, when the first row of lights should be located about 12 to 18 in. nearer the wall than the edge of the bench. If the room is divided into bays by deep girders or columns, each bay should be treated as far as possible as a unit, and the lights so spaced as to avoid shadows from the columns. If the size of lamp first selected does not give a suitable number for convenient location, a different size should be chosen and another arrangement tried. It is, of course, desirable to use as large a unit as possible, to reduce the cost of the wiring; on the other hand, a smaller unit gives more uniform distribution of the light, greater freedom from shadows, and less trouble due to one light being extinguished. With a smaller unit it is also possible to arrange a more flexible method of control, allowing some of the lamps to be extinguished during a part of the time, and resulting in a saving in power.

In the example selected, the basement requires about 0.3

watt per square foot. From Table 4 either 40- or 60-watt lamps could be used. From Table 5 it will be seen that 40-watt lamps, to give 0.3 watt per square foot, must be spaced on 11-ft. 6-in. centers. This does not work in well, since the bays are 15 ft. wide. If 60-watt lamps are selected the spacing could be 14 ft. 2 in., which would allow one lamp in each row per bay. Allowing four rows—two either side of the line of columns—gives a total of 36 lamps or $36 \times 60 = 2160$ watts, which gives $\frac{2160}{6210} =$ 0.35 watt per square foot. The spacing of the rows would be $\frac{46}{4} = 11$ ft. 6 in., the two rows next the walls being 5 ft. 9 in. from the wall.

For the first floor about 1.5 watts per square foot will be required. From Table 5 it will be seen that a 100-watt unit would give a spacing of 8 ft. 2 in., and from Table 4 that this size is suitable for the height of ceiling. Therefore, two units per bay can be allowed, giving a spacing of 7 ft. 6 in. With six rows there would be a total of 108 units, requiring 10,800 watts. This is equivalent to 1.74 watts per square foot, which is somewhat more than was assumed. If the same number of 60-watt units were selected, a total of 6480 watts would be required, or 1.04 watts per square foot. Because of the columns through the center seven rows could not be used and with eight rows the spacing would be too small and the cost of installation too great. The distance between the wall and the first row would ordinarily be one-half the distance between the other rows; but in this case, as there would be benches along the walls, the rows next the walls could be located 2 ft. away and the other rows spaced evenly, giving about 8 ft. 5 in. for the distance between these rows. The other floors would be treated similarly. If there are no beams to divide the room into bays, the problem is simplified, but it must be remembered that the lamps should be located in the center of the square or rectangle and not at the corners; see Fig. 2.

Vacuum Heating Systems

By W. L. Durand

The use of vacuum heating systems has increased to such a large extent in the last few years that a general description of this method of heating may be of interest to engineers who are not familiar with it.

The advantages of a vacuum system over a gravity system may be summarized as better circulation, the use of smaller pipes and the absence of air valves. In buildings with steam power plants, when the exhaust steam is in excess of the requirements for heating, a vacuum heating system is a distinct factor for economy, since the back pressure on the engines can be reduced to atmospheric, thereby correspondingly decreasing the water rate of the engines, and for very high buildings, buildings with large floor areas, or a group of buildings, a vacuum system is practically the only type of steam heating system that will work satisfactorily.

One of the claims set forth by the manufacturers of vacuum valves is that wide variation in temperature is permissible. This is, however, more a talking point than anything else, as in the best-designed systems the pressure in the radiators is rarely lower than 2 in. of vacuum or more than two pounds above atmosphere, or a range of only about 10 deg.

There are three types of vacuum return valves on the market—the float, the thermostatic and the differential. The float type acts on the principle of a bucket trap, the condensed water raising a float which opens an outlet that allows the water to run out until just enough is left to maintain a seal, when the outlet is closed. A very small opening is left for the air to escape. This type of valve has the disadvantage that the opening for the escape of air allows steam to leak into the return lines, keeping the temperature of the returns so high that it is necessary to use an injection of cold water at the pump to maintain the desired vacuum.

In almost every case the manufacturers of the float type of valve have gone over to the thermostatic type. In this a hollow metal disk, usually made of copper, is filled with one or more liquids that vaporize at or around 200 deg. The action of this valve is extremely simple. Any air or condensed steam of a lower temperature than the valve is set for passes through the outlet, but as soon as steam reaches the disk the expansion of the liquid inside shuts the valve off. The advantage of this over the float type is that it is noiseless and does not pass steam, thus doing away with the use of jet water at the vacuum pump.

Thermostatic valves may be divided into two classes—one in which the expansion disk is on the pressure side of the valve and the other in which the disk is on the vacuum side. In most cases either kind of valve works satisfactorily, but experiments have shown that those with the disk on the pressure side can carry about 20 in. of vacuum, as against 10 in. for the other kind.

The third type of vacuum return valves is used on what is known as th differential system. In this a weighted check valve with restricted orifice is placed on the return side of each radiator. These valves are placed at different points, usually at the bottom of each return riser on the end of a horizontal run. The valve disk is weighted with a number of lead disks, the size of opening and weight of disks being so proportioned that for each lead disk a difference of pressure of 1 in. of mercury is required to lift the valve. By varying the number of disks any vacuum from 2 in. or 3 in. to 15 in. can be carried, as may be desired. This is the only type of valve by which the vacuum carried can be so varied, a feature which is advantageous for systems spread out over large areas or which have long horizontal runs.

In its installation a vacuum system is no different from a gravity system except that smaller pipes can be used, especially for the returns, and the vacuum valves are placed on the radiators and no air valves are used. The main return line is carried through a strainer to the vacuum pump, which can be either steam or electric driven, and from there it is pumped to a small tank with a vent open to the atmosphere. This relieves the tank of entrained air, and the return water is either fed direct to the boiler or through a feed-water heater.

It is not advisable to cover the returns in a vacuum system, as the exposed pipe surfaces allow the water to become sufficiently cooled for operation of the vacuum pump without the use of jet water. Where vacuum return valves are used dirt pockets should be provided, and in starting a new system the interiors of the valves should be removed and the system should be operated for four or five weeks as a gravity system.

The Peterson Power Plant Oil Filter

This filter, which is manufactured by the Richardson-Phenix Co., Milwaukee, Wis., embodies new principles of oil purification. Its operation is as follows:

The dirty oil enters through the strainer box at the top and passes down through the removable strainer, where large particles of foreign matter, such as waste and the like, are strained out; the oil then goes to the heating tray where its viscosity is reduced. It then flows to the compartment below the heating coils and down through the funnel. The further operation of the precipitation compartment is more clearly shown in Fig. 2.

Passing down through the tube conductor, the oil is spread out by a baffle under the lower tray. Under the action of the greater head which builds up in the tube conductor, the oil is forced to take a zigzag path upward, passing under and over several trays, as shown by the lines of flow. It then passes out through the opening below the heating tray to the filtering compartment. The separated water collects in the bottoms of the different trays and is bypassed to the bottom of the precipitation compartment by means of funnels that surround the tube conductor, and does not again come in contact with the traveling oil.

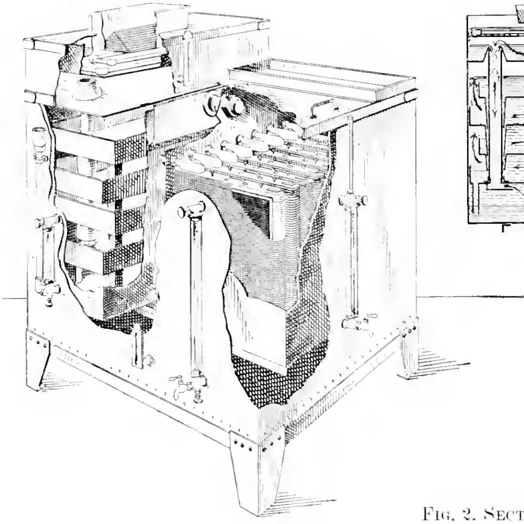


Fig. 1. Showing Interior Construction of the Filter

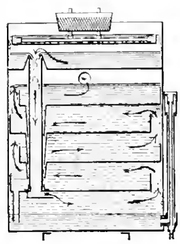


Fig. 2. Section through Water-Separating Chamber

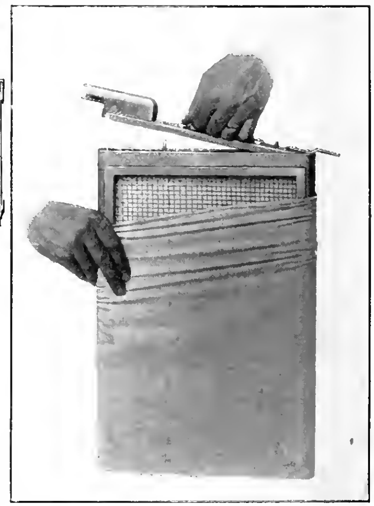


Fig. 3. Noncollapsible Filtering Unit

The water which is removed by the precipitation process is automatically ejected by an overflow tube at the right, which consists of two concentric pipes. The water flows upward through the outer tube and spills over the top of the funnel. The lower end of the tube can be connected to a sump or sewer. The funnel is threaded and can be raised or lowered, providing for proper adjustment for oils of different specific gravities. This water overflow simply operates on the U-tube principle; that is, the column of water in the outer pipe balances a column in the filter made up partly of oil and partly of water. As oil is lighter than water, the top of the overflow is a little lower than the level of oil in the precipitation compartment. As more water is precipitated out of the oil, the water level in the precipitation compartment tends to rise and the leg of the U-tube, which is inside the filter, becomes heavier because it is made up of a greater proportion of water and less of oil, thus water flows over the top of the funnel until the two legs of the U-tube again balance. In this way a low-water level is automatically maintained in the precipitation compartment.

Referring to Fig. 1, the level of the oil in the top tray is maintained constant by the skimmer, and the oil then flows through a pipe into the filtering compartment, which contains nine noncollapsible filtering units, such as is shown in Fig. 3. The oil passes from the outside to the inside of the filtering units, then out through the nozzles which project through the wall of the filtering compartment, to the clean-oil compartment. The nozzles on each unit fit into a spring-actuated valve so that any individual unit can be withdrawn and cleaned without interfering with the continuous operation of the filter. When the unit is withdrawn, this valve closes and prevents unfiltered oil from flowing into the clean-oil compartment. The filtering cloth is so arranged that it is free from folds or plaits, thus rendering every square inch active in filtering.

No oil can pass to the clean-oil compartment until the level in the filtering compartment reaches the outlets. Thus no filtering takes place until every square inch of cloth is submerged in oil; then as soon as a slight head builds up over the outlet, the process of filtration begins and is distributed over all of the surface, which is subjected to equal pressure.

The head of oil over the filtering disks is shown by an indicator at the top of the gage. When the filter is being operated at normal rating this gage should show a level of about three inches. If a greater height is indicated it shows that the oil is not passing through the cloth as fast as it should and that the cloths need cleaning. The filters are rated at 3-in. head over the filtering disks, but space is provided for carrying a 6-in. head. Thus the apparatus is capable of handling short overloads of 100 per cent., so that in case a large batch of oil should be run in, the filter will be able to take care of it.

The advantage in arranging the filtering cloth in a vertical position and having the oil pass from the outside to the inside of the units is that the slime and sediment which collect on the cloth continually work toward the bottom and drop off, thus automatically tending to keep the surface clean. The filtering medium is a special grade of cloth that does not act as a screen, but actually filters the oil largely by capillary action.

The water level in the precipitation compartment should be carried as low as practical. The gage shows the clean-oil level. The cock on the fitting at the bottom of this gage provides for withdrawal of clean oil to use in cans for hand oiling. The right-hand gage shows the level of the oil in the filtering compartment. This should at all times be full of oil.

All of the level gages have sheet-metal guards in back of them which are white enamel on the inside. This makes it easy to see at a distance the oil level and also protects the glass from breakage.

A thermometer shows the temperature of the oil before it enters the precipitation compartment, thus enabling the engineer to adjust the quantity of heat supplied so that the proper viscosity will be maintained. Another thermometer shows the temperature of the oil in the clean-oil storage compartment.

The filter body is constructed of galvanized sheet steel reinforced with channel and angle iron. All joints are lapped and closely riveted and soldered.

The only parts needing periodical cleaning are the filter cloths. The filtering units can be easily removed without interfering with the continuous operation of the filter and should be lifted out and set in a pan of kerosene or gasoline and brushed down with a stiff brush; this is possible because all the sediment collects on the outside of the cloth. Occasionally, the cloths can be removed and washed in gasoline or kerosene to thoroughly clean them.

The filter is built on the unit principle, and has been constructed with a capacity of 7500 gal. per hour in a single unit.

Don'ts for Refrigerating Engineers

By Thomas G. Thurston

SYNOPSIS—Thirty-four sensible "don'ts" for the operating engineer handling refrigeration machinery.

Don't start an ammonia compressor without first noting that the discharge valve is open. The writer remembers when this was overlooked in starting a 250-ton vertical machine, and two men who were working up under the ceiling above the machine came near being overcome with the gas. If the machine is not provided with a relief valve, the head is liable to be blown off.

Don't forget to turn the water on the condenser just before or immediately after starting the machine. If this is not done until the head pressure becomes high, leaks are liable to start in the condenser, both from the excess pressure and the increased temperature. If allowed to go too long the results will be as bad as forgetting to open the discharge valve.

Don't neglect to watch the head pressure while starting. The header valve on a condenser had been shut, and the operator, in a hurry to start, forgot it and blew the relief valves. Watching the head pressure will warn you, if you have forgotten it, to turn the water on the condenser.

Don't be in too much of a hurry to open the suction valve when starting, especially if the machine has been shut down for a long time, without pumping down the expansion coils and suction line. Open the valve slowly and keep your hand on the discharge pipe if possible. If this suddenly gets cold and the discharge valves begin to work unusually quietly, there is liquid coming back with the gas and the suction valve must be choked off until the machine begins to warm up again, otherwise it may wreck the compressor and may cause loss of life. If there is a slamming, or pounding, in the cylinder similar to an engine getting a dose of water, shut the suction valve until it stops, as this is an indication of a dangerous condition.

Don't forget to close the suction valve when shutting down even for a little while, and don't forget to close the liquid valve in the liquid line from the receiver to the expansion coils, or to close the expansion valve when shutting down a machine, if it is working alone. If these are not done the liquid will accumulate in the expansion coils and the suction line and make trouble when starting up again, or until it is pumped out.

Don't forget to watch the stuffing-box when starting up. This usually has to be tightened when the machine has been shut down for a long time, and it must be let out again gradually as the rod and packing warm.

Don't try to run the packing after it gets burned or hard and loses its resiliency. It will wear the rod and waste ammonia. Packing is cheaper than new rods or ammonia.

Don't run the crossheads too loose on an ammonia compressor, and don't tighten the crosshead shoes any old way. Either will make trouble in the stuffing-box. Put the compressor crank on the crank-end center and adjust the shoes so that the piston rod is the same distance from the guides at both ends of the stroke.

On the compressor the thrust of the connecting-rod usually presses the crosshead against the top guide except when the crank passes the center, when the weight of the crosshead drops it down on the bottom guide. If the crosshead is loose this will cause the packing to leak and wear it out quickly. This applies only where the engine and compressor are placed parallel, or side by side; if they are placed tandem, or opposite each other, the thrust on the compressor crosshead is the same as on the engine, and the guides should be adjusted accordingly.

Don't use more oil than necessary. If more is used it gets through the packing into the cylinder or goes out through the gas relief line into the suction pipe and the machine and out into the system, where it makes trouble.

Don't pump oil into the compressor cylinder. Usually enough oil leaks in through the stuffing-box and the gas relief line in addition to what circulates around the system to keep the compressor well lubricated. The only exception I have ever found to this was a 200-ton vertical double-acting machine. On this we had to pump about one-half pint every twenty-four hours into the top of the cylinders to keep the discharge valves working freely and to lubricate the cylinders.

Don't neglect to blow down the oil traps regularly. If you are not using more than a quart of oil every twenty-four hours, blow the traps at least twice a week, although every two or three days is better. If more than this is used, blow them at least every two days, and if the oil consumption is a gallon a day they should be blown every day.

Don't run the compressor excessively hot or ice cold; either one means loss of efficiency and capacity. The best results are had in the average plant by keeping the temperature of the discharge so hot that the hand can be held on it without burning.

Don't circulate water in the water jacket if the water is not warmer on leaving the jacket than on entering. To do so wastes water and refrigerating capacity.

Don't be satisfied with any suction pressure. Experiment with the expansion valves and see how high you can get the pressure without making the machine too cold; then try and keep it there unless the temperatures drop.

Don't run with a high head pressure unless it costs more for water to keep it down than for coal to pump against it.

Don't neglect to purge the air and foul gases out of the condenser regularly; this will help to keep the head pressure down. Any time the head pressure begins to climb without apparent reason or some of the coils get cold it is an indication of air or foul gas in the condenser, and the latter should be purged.

Don't neglect to pump out the air before starting in case any part of the system has been opened for alterations or repairs; it will save the trouble of purging it out of the condenser later on and save ammonia, as some ammonia always escapes with the air when purging.

Don't pump a vacuum on the system unnecessarily; it is likely to draw air into the system, and you will have to purge it out again.

Don't run with an insufficient charge of ammonia; keep enough in the system so that there is at least from four to six inches in the gage-glass on the ammonia receiver when running at maximum capacity. If the liquid level gets too low, some of the gas will pass over to the expansion coils with the liquid. Power has been used to compress this gas and water to cool it, and when it passes the expansion valve it will take some of the liquid that you have spent power and water to produce to cool it to the temperature of the suction gas. You are not only doing useless work in compressing and cooling the gas, but doing so absorbs some of the useful work already done, reducing the capacity and increasing the cost of operation.

Don't neglect the ammonia leaks. It does not take long for a dollar's worth of ammonia to leak out if there are a few small leaks in the system. Every week go over the points in the system with a lighted sulphur stick. The machine, and the high-pressure side of the system especially, need watching. Test the condensing water, jacket water and brine with litmus paper or Nessler's solution.

Don't neglect to shut the water off the condenser if it is shut down for any length of time, especially if it is old and subject to leaks; allowing the water to circulate over it cools it too quickly and may start a number of new leaks.

Don't neglect to clean the frost off direct expansion coils. The best way to do this is to run a hot gas connection from the discharge of the machine to the liquid line and pump hot gas into the coils; this will clean them quickly and thoroughly. Clean coils mean lower temperatures or the same temperatures at a reduced speed of the machine and therefore reduce the operating cost.

Don't neglect to inspect the valves and the false heads if there are any; see that they seat well, that the springs are not broken and are of the proper tension, and that there are no scored places on the seats and valves where the gas can blow through.

Don't neglect to pump out thoroughly before opening any part of the system for alterations or repairs; some men have a habit of letting whatever gas is in the machine blow to the four winds. It is just as easy to pump it out, much nicer to work around, and it saves the ammonia.

Don't break open an ammonia joint or any part of the system until you are certain the pressure is off, and don't be too quick in opening it even then. Loosen the bolts a little and open the joint easily. In case there should be pressure on it you can draw it up again before it gets too strong for one to stay around it. You will at least have a good chance to get away. Some men have lost their lives by neglecting to take this precaution.

Don't pull up too hard on a joint that is under pressure; you may break the flange, lose your life, and a part of the ammonia charge. If a joint does not stop leaking after it is drawn up reasonably tight, pump the line out and renew the gasket.

Don't get excited in case anyone gets a dose of liquid ammonia or ammonia-saturated oil; douse him with water. Turn the fire hose on him if there is one.

Don't connect a stop valve in an ammonia line so that the flow of the gas or liquid tends to close the valve. The writer remembers two cases where the valves came off the stems and caused much trouble. In one case the valve shut off the flow and blew the relief valve on the compressor. It took much time to locate the cause. In the other case the valve did not stop the flow, but hammered back and forth on the seat, wearing the disk and seat so much that a new valve was needed.

Don't neglect to keep the oil out of the expansion coils. If there are signs of oil in the system, open the coils as soon as they can be spared and blow them out, first with steam and then with air, and be sure they are thoroughly dry before closing them.

Don't open or shut a valve without first checking to make sure that it is the right valve.

Don't be in too much of a hurry when pumping an air-pressure test with an old machine on a system that has been in service for a long time. If there is oil in the machine or discharge line, it may cause an explosion due to the compressor getting hot enough to ignite the oil. Run the machine slowly and keep plenty of water on the water jacket if it has one. If the machine or the discharge line gets very hot, shut the machine down until it cools.

Don't forget to keep up a rapid circulation of water when pumping out a double pipe or a submerged condenser. Otherwise it will freeze and burst. The same also applies to a brine cooler.

Don't leave the suction lines uncovered outside of the coolers. It means extra work without anything to show for it.

Don't run an ammonia plant without an ammonia helmet. When something blows out some day it will save its cost in ammonia and may save life.

"Defender" Boiler-Room Appliances

The accompanying illustrations show the principal portable instruments recently developed by the Defender Automatic Regulator Co., Oriel Bldg., St. Louis, Mo. are made in two sizes, one for collecting over an 8-hr. period and the other over a 24-hr. interval. The collection chamber is tapered to compensate for the change in the rate of flow of the water from the chamber due to the decrease in static head as the water lowers in the

Fig. 4. Duplex Draft Gage

vessel. Consequently, the gas is drawn in at a constant rate and an average sample for the entire period is obtained. A gage glass on the collector is provided to indicate the height of the water at any time.

Fig. 4 illustrates a "duplex" draft gage for indicating the draft in the furnace and at the damper or stack, and the drop in draft through the boiler. Outlet *A* connects with the lower or longer tube, which has a range up to 1 in. and is generally used for the uptake

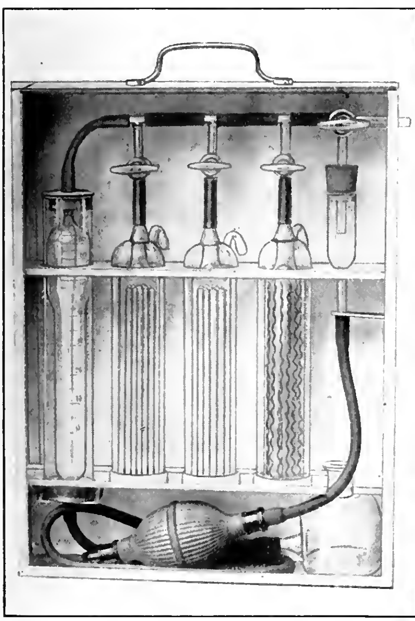


Fig. 1. Three-Pipette Machine

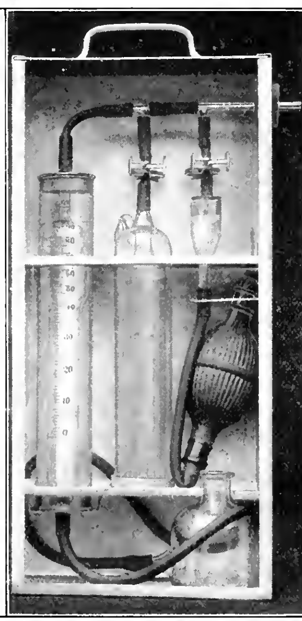


Fig. 2. Single-Pipette Machine

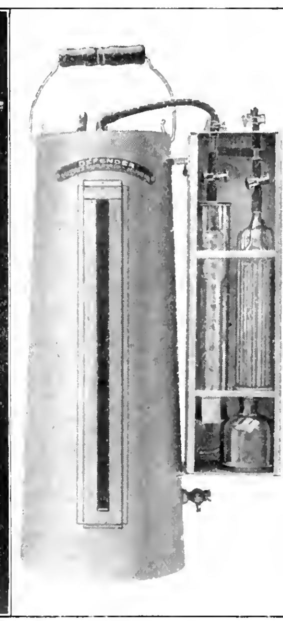


Fig. 3. Gas-Sample Collector

Fig. 1 is a modified type of Orsat with three pipettes for determining the CO_2, O and CO contents of the flue gases. The case and covers are of metal, and the header, ordinarily of glass, is here made up of rubber connections and glass tees, not subject to breakage.

A single-pipette apparatus for use where the CO_2 content only of the gases is required is shown in Fig. 2. Fig. 3 is a combination gas-sample collector and CO_2 analyzer. Where desired the gas-sample collector is furnished without the analyzer attached. The collectors draft. Outlet *B* connects with the shorter tube, which has a range up to 0.9 in. to measure the furnace draft. The difference between the two readings gives the drop in draft through the boiler. These gages are furnished mounted in either an inclosed or open aluminum case.

In addition to the instruments illustrated the company also makes a high-range brass-inclosed thermometer for flue-gas temperature observations, single-tube draft gages and a "multiple" type draft gage mounted on a wooden panel for direct attachment to the boiler.

Saving in Federal Building Plant

Since its inception in 1905 the Federal Building in Chicago has been equipped with a boiler plant to supply steam for hydraulic elevator pumps, engine-driven air compressors serving a pneumatic-tube service, fan engines, boiler-feed and service pumps, and some live steam for the heating system. The exhaust from the units just mentioned only supplied about half the heat requirements of the building in the colder weather. Current for light and power had been purchased from the central station at a price of 1.9c. per kw.-hr. for the first 100,000 kw.-hr. per month, and 0.9c. for all current in excess of this amount. Eventually, it was decided to install a generating plant that would produce all the current needed and at the same time furnish more exhaust steam to the heating system. This equipment was described in the Apr. 28, 1914, issue of Power, and from the saving made in the first month of operation it was estimated that the gross saving would exceed $14,000 a year. As shown in the accompanying table, this estimate has been exceeded by nearly $2000. In exact figures the gross saving effected by the plant during its first year of operation was $15,984.70. The total investment for the generating units and all additions to the plant was $43,000. Allowing 5 per cent. for depreciation and 3 per cent. for interest, which is more than the government usually receives, gives $3440 to be deducted from the total saving. This still leaves a balance of $12,544.70, which is over 29 per cent. on the investment and indicates that the plant will pay for itself in about 3½ years.

In the previous article the entire equipment was given in detail and in the following it is briefly summarized. The building is equipped with 45,000 sq.ft. of indirect and 65,000 sq.ft. of direct radiation on a two-pipe vacuum system. Seven passenger elevators of 3000 lb. capacity each, four 4000-lb. freight elevators and four 2000-lb. hydraulic lifts are served by one pumping engine, 16&20x20x5¼x24 in., and two duplex tandem-compound pumps, 16&25x7⅜x18 in., working against a water pressure of 750 lb. For the pneumatic-tube mail-handling system there are four air compressors driven by cross-compound engines ranging in capacity from 75 to 125 hp. There is also a 20-ton absorption refrigerating system to cool the drinking water. To serve this equipment, five 350-hp. water-tube boilers had been installed. This gave plenty of reserve capacity for the generating plant. Incidentally, its installation did not increase the number of boilers in operation. There was plenty of unused space in the basement for the four generating units which were eventually installed. Two of these are 200-kw. machines and two 100-kw. generators directly driven by four-valve engines.

Steam flow meters are installed for the different services, and a water meter measures the total amount of boiler feed. The monthly and yearly totals, as read from these meters, are given in the table. With more exhaust steam to heat the feed water, it will be noticed that the average evaporation per pound of coal is 8.18 for 1914-15, as compared to 7.3 for the previous year. About the same amounts of steam went to the elevator pumps and to the air-compressor engines. The live steam to the boiler-feed pumps, fan engines, heating system, etc., was considerably less, as there was more exhaust available for the

OPERATING DATA OF FEDERAL BUILDING COVERING PERIOD OF TWO YEARS

Year Month	Deg.-Hr. per Mo. below 70 Deg.	Av. Temp. Feed Water from Heater, Deg. F.	Av. Temp. Feed Water from Econ., Deg. F.	Av. Steam Pressure, Lb. Gage	Av. Evap. per Lb. Coal	Steam Supply: To Elevator Pumps, Lb.	Steam Supply: To Pneumatic Tube Compressor Engines, Lb.	Steam Supply: To Pumps, Fans and Heating System, Lb.	Steam Supply: Steam to Gen. Units, Lb.	Blowdown Water, Lb.	Total Water to Boiler, per Month, Lb.	Coal per Month, Long Tons	Power, Kw.-Hr. per Mo.	Light, Kw.-Hr. per Mo.	Total, Kw.-Hr. per Mo.	Cost of Current, per Mo.	Operating Expense	Saving Over Previous Year
1913—March	26,090	187	248	156.9	7.1	1,808,995	1,278,115	6,282,729	....	129,115	9,498,954	587.75	26,130	84,210	110,340	$2,067.60	$6,019.07	
1913—April	15,336	179.9	244.9	156.2	7	1,778,109	1,171,217	3,851,117	....	124,950	6,925,393	433.82	27,690	80,380	108,070	1,912.91	5,415.44	
1913—May	9,336	196.3	245.7	156.5	7.4	2,021,948	1,506,844	2,354,873	....	129,115	6,012,780	352.8	35,340	79,220	114,560	2,007.26	5,033.12	
1913—June	3,932	197	246.6	157	7.8	1,679,797	1,779,345	1,374,225	....	124,950	4,958,317	281.95	36,310	72,000	108,310	1,926.31	4,858.21	
1913—July	576	192.6	242.7	157.6	7.1	1,732,052	1,872,207	1,453,242	....	103,292	5,160,793	315.95	39,090	70,790	109,880	2,036.87	5,117.06	
1913—Aug.	432	206.8	246.8	157.1	7.2	1,883,808	1,405,634	1,602,891	....	77,469	4,969,802	302.35	41,560	70,010	111,570	1,936.32	5,025.96	
1913—Sept.	5,470	189.4	251	157	8	1,936,532	1,152,609	2,926,153	....	126,616	6,141,910	336.8	61,440	72,310	133,750	2,054.89	5,173.53	
1913—Oct.	12,897	174.2	249.1	157.6	7.3	1,853,233	1,468,586	3,600,408	....	103,292	7,025,519	419.95	74,280	84,940	159,220	2,190.06	5,795.16	
1913—Nov.	16,488	169.6	242.3	157	7.0	1,872,223	1,114,177	4,128,980	....	99,960	7,215,340	456	65,560	82,380	147,940	2,221.30	5,708.30	
1913—Dec.	26,136	165.2	236.8	156.6	6.8	2,013,413	1,175,216	5,573,421	....	103,292	8,865,342	576.04	54,000	93,990	147,990	2,270.78	6,353.60	
1914—Jan.	27,888	164.5	232.6	157.6	7.7	1,929,767	1,203,562	8,449,826	....	103,292	11,686,447	673.85	46,080	93,180	139,260	2,206.90	6,575.83	
1914—Feb.	38,480	177.2	243.9	157.8	7.3	1,800,900	798,549	9,418,885	....	93,296	12,111,630	733.72	36,970	81,810	118,780	2,026.55	6,685.70	
Totals	183,061	183.3	244.2	157.1	7.3	22,310,777	5,926,061	51,016,750	....	1,318,639	90,572,227	5470.98	544,450	965,220	1,509,670	$24,857.75	$67,760.98	
1914—March	25,384	182.2	248.8	151.5	6.6	2,045,846	970,535	7,625,645*	....	103,292	10,745,318	713.0	45,460	89,880	135,340	....	$4,519.96	$1,499.11
1914—April	15,624	193.2	256	148.9	7.3	1,743,781	924,626	7,264,331*	....	99,960	10,032,698	611.6	53,360	82,730	136,090	....	4,294.73	1,120.71
1914—May	6,936	195.7	259.4	149.7	7.5	1,665,266	946,364	1,659,421	5,069,864	103,292	9,444,207	556.1	37,850	86,440	124,290	....	4,162.51	870.61
1914—June	2,688	202.4	261.4	150.6	7.0	1,906,813	871,935	1,573,619	3,969,756	99,960	8,422,083	527.2	36,580	73,470	110,050	....	4,061.22	796.99
1914—July	202	202.2	261	151.9	7.2	1,849,427	1,010,533	1,307,654	4,184,630	103,292	8,455,536	524.3	34,050	71,890	105,940	....	4,018.85	1,098.21
1914—Aug.	624	203.9	257.2	151.5	7.1	1,469,377	955,928	1,074,251	4,291,060	103,292	7,893,908	489.8	32,800	71,860	104,660	....	3,985.92	1,040.04
1914—Sept.	3,192	201.6	254.6	152.4	8.5	1,763,252	1,585,416	1,074,251	4,833,440	99,960	9,356,319	492.5	31,480	75,190	106,670	....	3,890.15	1,283.38
1914—Oct.	7,732	197.1	253.2	152.4	9.9	2,222,275	1,745,820	3,040,307	5,688,493	103,292	12,800,187	577.9	35,890	85,300	121,190	....	4,341.50	1,453.66
1914—Nov.	18,816	165.5	234.6	151.7	8.3	2,036,190	1,522,902	2,385,018	5,188,156	99,960	11,232,226	607.8	33,100	79,680	112,780	....	4,280.50	1,427.80
1914—Dec.	34,272	174.6	243	151.1	9.3	2,394,975	1,717,518	6,172,714	7,487,642	103,292	17,876,141	798.6	32,760	94,990	127,750	....	4,899.01	1,454.59
1915—Jan.	32,256	181.2	244.8	150.7	9.8	2,509,650	1,576,644	7,489,192	6,595,082	103,292	18,273,860	825.6	31,760	92,970	124,730	....	4,956.70	1,619.13
1915—Feb.	23,078	180.1	240.3	152	9.7	2,221,622	1,457,394	5,368,602	5,519,299	93,296	14,660,213	672.7	31,160	83,400	114,560	....	4,365.23	2,320.47
Totals	170,804	189.9	251.1	151.4	8.18	23,828,474	5,285,615	46,035,005	52,827,422	1,216,180	139,192,696	7397.1	436,250	987,800	1,424,050	....	$51,776.28	$15,984.70

*Includes steam to generating units.

heating system. From the 1st of May to the end of February the engines used 52,827,122 lb. of steam. Dividing by the total kilowatt-hours generated in the same period, the consumption per kilowatt-hour is 15.8 lb. During the night hours the engines operated at light loads and the pressure was dropped to 140 lb., as compared to 160 lb. during the day. Besides, in the early part of the year all of the units were tuned up and more machines operated than were necessary. These factors account for a water rate which is higher than may be expected in succeeding years.

With the demands made by the other services about the same, the generating plant caused an additional operating expense of $8873.05, excluding the amount paid for central-station current. Dividing by the total output, the cost per kilowatt-hour amounted to 0.623c. The increase in coal consumption was 1926 tons, and to operate the generating units two extra men were required. The wages for these extra employees, coal at an average of $3.01 per ton and the additional oil and supplies required made up the excess in operating cost just referred to.

When the $24,857.75, the amount paid the central station for current, is added to the operating expenses of the plant, the total of $67,760.98 for the year ending February, 1914, exceeds the total expense for last year by $15,-984.70. It is true that the current used during the year was less by 85,620 kw.-hr. More current was used for lighting, but the power demand was considerably reduced owing to changes in the service and to doubling up motors, making one do where formerly two had been employed. Had it been possible to reduce the electrical service in 1913 to the same figure, the amount paid for current would have been reduced $770.58, as the excess came under the 0.9c. rate. Putting both years on an equal basis, the gross saving would then be $15,214.12. Deducting the $3440 for interest and depreciation leaves a net balance of $11,774.12, which is 27.4 per cent. on the investment of $43,000.

Ratio of Circumferential to Longitudinal Stresses in Boiler Joints

By J. K. Linderhurst

SYNOPSIS—The article considers those conditions which sometimes make the ratio of the circumferential to the longitudinal stresses more than two to one.

The average engineer who knows how to calculate the strength of boilers usually believes that estimating the strength of a cylinder to resist internal pressure is a simple problem. If all the factors are considered the problem is not simple, and the calculation of the correct efficiency of the longitudinal joint, usually considered the most difficult part of the problem, is one of the simplest.

Fig. 1, for example, is a part of a seamless cylinder, and if one were asked what is the relation between the circumferential and lengthwise stresses, he might state at once that the former is just twice the latter. The mathematical demonstration that this is so is apparently simple, for if the portion of this cylinder is taken of such length that the lines LM and KN equal the circumference of the cylinder, then the area on which pressure is exerted and tends to produce rupture is $2r \times LM$, when r is the radius of the cylinder.

The area exposed to pressure that will exert a lengthwise stress is the internal cross-sectional area of the cylinder, or $3.14r^2$. Now, since we have taken LM equal to $3.14r$, or one-half of the circumference of the cylinder, the first expression for area becomes $2r \times 3.14r$, or $6.28r^2$, which is twice the amount of the figure expressing the area of the internal cross-section, and therefore the lengthwise stress should be one-half of the circumferential.

No attention was given to thickness in making these calculations, for the shell was considered as a line without thickness. In Fig. 2, the thickness of the cylinder is indicated by the cross-section lines, and it is seen that if the circumference on the diameter KL is equal to LM and KN, the area of metal along LM and KN will not quite equal the cross-sectional area of the shell as indicated by the section lines, because this area equals the thickness times the mean circumference, which is halfway between the outer and inner surfaces, and not the thickness times the inner circumference.

Another factor not usually considered, and one which makes the difference between the longitudinal and maxi-

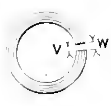


FIG 3

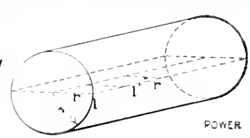


FIG 4

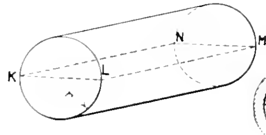


FIG 1

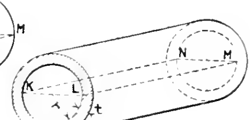


FIG 2

Illustrating Relation of Circumferential to Longitudinal Stresses in Boiler Joints

mum girthwise stresses greater than the one to two ratio, is as follows:

In considering the strength of cylinders, where the thickness is small as compared to the diameter, it is not customary to assume that the circumferential stress is unequally distributed over the thickness of the plate; but such is the case and, instead of the stress being equal throughout the plate thickness, it is greatest along the inner surface and least along the outer. No stress within the elastic limit of a material can be applied without producing corresponding stretch. Since a cylinder cannot increase in diameter without stretching the inner surface a proportionately greater amount than the outer, the stresses in the plate will not be uniform. This is evident, if we consider a cylinder made up of concentric layers, as in Fig. 3. If such a cylinder were cut open to be free to expand, internal pressure applied to increase the diameter would cause the dimension W, which is the amount of separation of the outer layer, to be equal to V, if the layers of material were very thin. This illustrates how the material is supposed to behave in a solid plate cylinder under pressure. Since the actual stretch of all layers is the same, the stress produced in them is not uniform, on account of their varying length. The difference in the strength of a cylinder calculated in this way and one figured in the usual way is expressed by the ratio between the length of the outer and inner circumferences of the shell; or, since these circumferences are directly proportional to their radii, the ratio would be that between the inner and outer radii. For example, in Fig. 4, if t were of such dimensions that it would equal one-quarter of r (r being the inner radius of the cylinder), then the strength calculated in the usual way would be

$$\frac{thickness \times strength\ of\ shell\ per\ sq.in.}{inner\ radius} = bursting\ pres.$$

Assuming r at 4 in. and, therefore, t at 1 in., and 50,000 lb. per sq.in. as the strength of the shell material, we have, as bursting pressure,

$$\frac{1 \times 50{,}000}{4} = 12{,}500\ lb.$$

If the fact that the circumferential stress is not evenly distributed in the shell is taken into account, the bursting pressure is found to be

$$12{,}500 \times \frac{inner\ radius}{outer\ radius},\ \text{or}\ 12{,}500 \times \tfrac{4}{5} = 10{,}000\ lb.$$

bursting pressure, which is a difference of 20 per cent.

In boiler shells, where the diameter of the boiler is large, as compared to the thickness of plate, neglecting this feature in estimating the strength is not of importance, but to show the effect it may be well to consider an example. Take a boiler of 60-in. inside diameter and made of ½-in. plate subjected to a pressure of 125 lb. per sq.in., the boiler being assumed to be seamless. The load carried in a girthwise direction is

$$125 \times 30 \times 2 = 7500\ lb.,$$

but as this load is not equally distributed throughout the thickness of the plate, the maximum fiber stress at the inner surface is about 7620 lb. per sq.in. The endwise stress is due to the pressure of 125 lb. on an area of 2827.43 sq.in., or a load of 353,428.75 lb. The area of shell available to support this load is 47.4 sq.in., which is the cross-sectional area of the shell. Therefore, the stress per square inch longitudinally is

$$\frac{353{,}428.75}{47.4} = 7456\ lb.$$

so that the highest fiber stress girthwise is something over 2 per cent. greater than the lengthwise stress in the shell of this boiler when considering it as a cylinder without tubes. As has been stated, the slight difference in calculating boiler shells by either method is not enough to warrant consideration. It is well, however, to know just what we are talking about when we state that the girthwise stress in a cylinder subjected to internal pressure is twice the longitudinal stress.

Some like to express the relative values of these two stresses graphically and state that, as in Fig. 4, if we take any horizontal length of the shell, as l, and a corresponding length on the circumference l, the pressure on the triangle inclosed by the two radii produces the stress lengthwise of the shell on the section 1 in. long, and that the stress in the circumferential direction is due to the pressure on the rectangle lr. Since the area of this rectangle is just twice that of the triangle, the stress due to the pressure is in the same proportion.

The difficulty in this case is the same as in the case of Fig. 1 as regards accuracy, for only lines have been considered without thickness. If the metal to stand the load is to be equal in both cases, the length l in the case of the circumference of the shell would have to be taken on the mean circumference, in which case the triangular area would not be one-half of the rectangular, and therefore the resulting stresses would not be in the ratio of one to two.

This latter method of comparing the values of the stresses in a cylinder is called the graphic method.

Specifications for Steam Lines

By D. Craft

In specifications for steam lines for power using high pressures of steam, a mistake is commonly made in calling for lines as large as the connections of all the engines and turbine. It appears to the writer that many of the small engines and turbines used in power-plant work are provided with connections which are made large enough to supply the steam required at the minimum pressure likely to be used by any purchaser for the maximum rated capacity.

In our plant the pressure carried is 175 lb. All of the smaller machines here were originally connected to steam lines out of proportion to their capacity. For instance, two 5-hp. Terry turbines driving hotwell pumps had 1¼-in. steam lines; a 6x8x6-in. air compressor compressing to 50 lb. had a 2-in. line; two 6x9-in. engines driving circulating pumps and carrying a 6-hp. load had 2½-in. steam lines, and there were several similar instances of excessive sizes of connections.

We have reduced some of these lines to one-sixth of their original capacity. In addition to reducing losses from saving radiation we have saved considerable in expense and annoyance of keeping large throttle valves tight, and there is a marked reduction of governor trouble. The large governor valves throttled the steam so closely that from wiredrawing of the steam the valves required frequent grinding, reseating and renewing.

By reducing the size of these valves and lines we have overcome our trouble. Where we made these reductions in pipe sizes the lines were made only large enough to transmit 30 lb. of steam per hour for each horsepower required, with an allowance of about 10 per cent. for drop in pressure.

The Most Economical Pipe Size for the average demand should be used, with provision for increasing the boiler pressure or opening a supplementary "booster" line during maximum demand when the engine cannot otherwise carry the load. Recent tests here and abroad prove that substantial saving may follow a reduction in pipe size or shutting off booster lines, thereby saving in condensation and radiation losses.

Editorials

Factors in the Engineer's Salary

What determines the contents of the engineer's pay envelope? Surely, in too many cases his salary, or whatever his remuneration may be called, is the result of custom on the part of the establishment which he serves—a sort of haphazard adherence to the "going" rate of pay in the local community in this occupation. Surely, there are other standards by which employers may fairly gage the worth of their engineers—standards which take into account their responsibilities, their service performance and powers of constructive suggestion.

Because a ten-thousand-kilowatt turbine today requires less attendance than a two-thousand-five-hundred-kilowatt engine-driven unit did a dozen years ago, some people doubtless think that the engineer has an easier time in a typically modern plant, and therefore is not entitled to higher compensation. Again, some hold that because a plant is put on an eight-hour shift where a ten- or twelve-hour schedule was formerly maintained, the engineer's duties are correspondingly lightened and he deserves little consideration in the direction of "raises."

If any single factor is to be picked out as paramount in rate-making for operating engineers, that factor should be responsibility. The value of the service rendered by the plant is one great test, and the value of the equipment in the engineer's charge is another. It matters little whether the machinery is highly automatic in its operation so far as engineering responsibility is concerned, compared with the amount of money invested in it and the penalties of service interruptions. There may be less manual effort in handling a fifteen-thousand-kilowatt turbine and its auxiliaries than in operating an engine-driven outfit of a fifth that capacity, but the risk of damage, the question of daily cost when such a machine stands idle, the importance of its output, and the value of technical judgment in inspection and maintenance, all tend to place the man in charge of high-powered units in a special class as regards payment—a class which is recognized in many concerns, but which on principle ought to be appreciated all along the line more than it is.

In a word, the hours of daily service should cut little figure in salary or wage determination, and the same may be said of the output per unit. At first blush, the plant turning out a big total of daily horsepower-hours might be set up as a standard of payment, but while peak loads increase the engineer's anxieties, the daily test of his work comes down to his ability to turn out whatever output the load demands, at the lowest cost consistent with reliable service. The ability to save the plant owner money, realized in the daily work of the engineer, should not go unrewarded. Profit sharing is just as good a plan in the power house as in the factory, but a good many employers have yet to realize it. Certainly, the engineer who works diligently to improve the efficiency of his installation, who studies how to make it yield the best possible service, and who knows from accurate records just what the physical results of those efforts are, is demonstrating his fitness for responsibility and is keeping his "cutting edge" sharp to good purpose.

Analysis of local conditions in power plants should accompany consideration of the problems of compensation in the future, and the farther the plant owner gets from mere imitation of what others are doing, the better it will be for all concerned.

Art and the Steel Stack

A chimney has two principal functions—one to produce a draft, the other to take the gases high enough above our heads so that we do not notice them. Until someone invents an invisible chimney we shall have to put up with tall tubes sticking up into the sky line.

Various attempts have been made to disguise chimneys in the interest of the artistic. Greek columns, campaniles and other architectural units have been pressed into service, but the incongruity of such works of art belching clouds of smoke has made them less artistic than the chimney which pretends to be nothing but a chimney. Brick and concrete afford materials which can be made more or less ornamental—the former by shape and color, the latter by shape alone. The steel stack seems seldom to be anything but a parallel tube without ornamentation.

A steel stack has very decided advantages from a financial point of view. If it had to be replaced every year it would cost only about what the interest would be on a brick stack and its foundation. As it lasts from five to twenty-five years, according to the coal and weather, there is little to be said against it except as a matter of looks. There is a prejudice on the ground that it will not draw, but that is probably ill-founded. If there were any great difficulty from radiation it could be helped by means of a jacket or an inner tube, neither of which is often resorted to. On the score of looks there is nothing that can be said in favor of the ordinary factory stack. A degree of ornamentation is sometimes attempted by painting colored bands or by lettering the name of the owner on the side, but that is bad in that it attracts attention to an ugly thing

It would seem as though a steel stack could be designed the lines of which would be at least pleasing when seen from sufficient distance so that the material was not in evidence. There is no insurmountable difficulty in making a tapering tube of steel. It is even possible to give it the slight swelling which appears to be necessary to make it look like a straight taper. The largest expense appears to be for an ornamental head, which may cost as much as the rest of the stack, but which, if made on simple lines relying on distance to obscure the lack of detail, should not be very expensive. Then if, instead of painting it a dead black, it could be made a gray or some neutral color, it would be still less noticeable, and that is the real object to be attained—practical invisibility, or making it attract as little notice as possible.

Looking Out for the Fine Points

The small details in the layout of a power plant, although often receiving scant attention, are important factors in its operation; and it is surprising how nearly every plant illustrates practice which is either worth following or which might well be avoided. Station lighting, for instance, too often receives insufficient consideration, particularly in the use of shades or reflectors capable of concentrating the light on machine parts needing frequent inspection or adjustment. Also, the use of unshaded lamps mounted low on columns in stations with high ceilings is extremely wasteful. Boiler rooms are notoriously ill-lighted in many stations, and here is a field for the practice of engineering skill along lines as yet relatively undeveloped. No lighting installation, however, will give adequate results if neglected as to periodical cleaning of fixtures.

The numbering of switches and motor starters to correspond with the apparatus controlled has important bearing upon convenience of operation. In emergencies requiring the sudden stopping of a motor-driven centrifugal pump and the starting of another, no time should be lost through the manipulation of the wrong switch. Similarly, the labeling of lighting switches with appropriately keyed circuit numbers, including specific areas covered, when feasible, is desirable. The mounting of generator field rheostats sometimes is a troublesome problem. In a recently completed station this apparatus was placed behind the switchboard, but so far above the floor as to obstruct the light from the windows, consequently it had to be blocked up with a wooden strut which obstructed the passage at the rear of the board. In a section of the plant containing refrigerating coils, lights were placed on the alternate stairway landings only, thus giving too dim an illumination for rapid and safe travel, and in the freezing room no effort was made to protect the local switches and fuses from vapors.

Although many of these loose ends are taken in hand after the plant is in regular operation, they are usually sources of inconvenience, extra cost, and danger, and should be guarded against wherever possible.

Making the Dollars Produce

Frequently, the operating engineer of a factory power plant is called upon to make changes or extensions to the existing plant, possibly occasioned by the addition of building or machinery made necessary by the desire of the owner for increased facility. At such times the importance of intimate knowledge of details of the existing power plant, together with the exact knowledge on the part of the operating engineer of the actual value utilized of the owner's dollar's worth of coal, cannot be too forcibly insisted upon.

The operating engineer who is content to just operate his plant without knowing exactly what part of the owner's dollar invested in the coal pile is being put to useful purpose, will fail when called upon for advice to meet the new conditions. He is the one who will sulk in the corner when the boss employs outside talent to solve his problems. In the corner with his face to the wall he will remain, for he has entirely neglected to grasp and use the opportunities given him.

How many operating engineers have traced the pound of coal fed to the boiler from the pile to the switchboard? How many ever stop to realize that only about fifteen cents out of a dollar's worth of coal actually reaches the switchboard? The missing eighty-five cents in too many instances is almost a total loss, whereas with proper knowledge and equipment as much as sixty cents of this can be saved and put to proper use.

The salesman who sold the engine and generator boasts about the combined efficiency of his apparatus being 95 per cent. This is not to say that the owner is getting ninety-five cents at the terminals of the generator on the dollar paid for coal. He is not. This combined efficiency means that for every hundred pounds of steam given the engine at the throttle, all the electrical energy that can be obtained from ninety-five pounds is realized at the terminals.

Possibly one will ask, why try to save the exhaust steam from the engine? The answer is that the steam exhausting from the engine contains more than twice as much heat value as is actually used in the engine and transformed into electrical energy.

The exhaust steam should be turned to good use, such as heating the buildings, or possibly supplying apparatus required in the process of manufacture, such as drying rooms and kettles, and also to heat the feed water supplied to the boiler, thereby reducing the work required from the coal.

Until recently, the owner invariably looked upon the coal bill as a necessary evil. Times are changing. The efficiency engineer is making rapid progress. Be in a position to tell the boss just where his dollar's worth of coal is going. Maybe, when he asks your advice on new equipment you can tell him that by making certain changes in the existing plant, there will be boiler capacity enough to carry the increased load, thus materially lightening the burdens on his pocketbook.

Don't wait for the efficiency engineer to tell your boss where his money goes; get there before him. You are the one that should tell him.

Is it any more onerous or less reasonable to require a user of a boiler to provide it with an adequate safety valve, than to require him to furnish an adequate fire pump; to insist upon an open exit from a fire-room which is liable to become a torture chamber filled with scalding steam from the bursting of a steam pipe or fitting or of a boiler tube, than from an ordinary workroom; to require the use of furnace doors which will not allow the fire to be blown out over the premises and the people, and to provide an outward escape for the steam and gas from a boiler setting in case of a bursting tube, than to insist upon guards around belts and flywheels? Has not "safety first" as much import in the power plant as elsewhere?

The head of an organization of steam-boiler firemen in New Jersey recently informed us that the educational work that has been vigorously conducted among engineers in that state during the past few years has had the effect of establishing unusually favorable relations between engineers and firemen. There is more thorough coöperation between the two today than ever before, he stated.

When the average man begins to educate himself he soon learns that he does not know as much about his calling as he thought he did. Once he is conscious of this, he is likely to be less arrogant and more helpful to his subordinates.

Correspondence

Maximum Lift of Steam Ejector

Referring to the request by Charles S. Palmer, as printed on page 481 of the Apr. 6 issue of POWER, and in particular to the question relative to the maximum lift that the steam ejector when applied to priming centrifugal pumps can be expected to develop, I offer the following:

The depth in feet from which the water can be raised to the pump by vacuum created by the ejector depends upon local conditions, such as tightness of piping and pump parts and the steam pressure used. Theoretically, it should be 33+ ft., which would indicate perfect vacuum, but in practice 25 ft. is near the maximum when the best range of steam pressures—40 to 80 lb. gage—is employed, and all valve stems, stuffing-boxes, pump and pipe joints are tight against air leakage. Usually considerable care must be exercised to keep the air leakage down to a minimum.

With Mr. Palmer, I should be much pleased to receive through your columns the common-sense explanation of the collapse of the discharge pipe on the pump mentioned in the article referred to.

PENBERTHY INJECTOR CO.,
L. A. PURCELL.

Detroit, Mich.

Priming a Centrifugal Pump

Some years ago I had the pleasure—and the work—of spending a season at a fairly large-sized irrigation plant in the cane and rice belt of southern Texas. I do not remember the capacity of the pumps, but it was considerable. There were two centrifugal pumps, each driven by a tandem-compound Corliss engine of the nonreleasing valve-gear type; the speed was 175 r.p.m. Each had a separate suction and discharge, the former being 72 in. and the latter 45 in. diameter.

These two pumps formed one of the two plants that were necessary to put water on the rice lands. The plant at which I was stationed was called the lower lift. It was on the Brazos River and the engine-room floor was about 50 ft. below the surrounding land level. This was necessary, as the water level in the river became low during the dry season, and then the pumps had about 12-ft. lift.

From the river the water was discharged into a canal about 35 ft. above the pumps. At low water this gave a total lift of something like 47 ft. The shaft stuffing-box was, of course, water-sealed. These pumps would easily lose their suction if they slowed down as little as five revolutions per minute below their regular speed. They always had to be primed when the water in the river was lower than the engine shaft. There was no valve in the suction line. The discharge line was provided with a gate valve operated by hydraulic pressure, which was usually assisted by a half-dozen men with chain blocks and bars.

There was a 4-in. steam ejector connected at the highest point in the pump case. Whenever a pump lost its suction it was stopped, the discharge valve closed and the ejector started. Sometimes the air would be dispelled and the case filled with water in from 15 to 20 minutes, but generally it took over half an hour and sometimes longer, owing to leaks in the pump and piping. The ejector took more steam than the engine and the boilers were crowded during priming. Often, while priming one pump the steam pressure would become so low that the other would slow down and also lose its suction. There were times when the ejector would just begin to discharge water when it would have to be shut off owing to the danger of the other pump slowing down.

As soon as the ejector began discharging a full stream the pump was started and brought up to speed as quickly as possible. The discharge valve was never opened till the pump was up to speed and then opened slowly. It was inconvenient to start either of these pumps with the discharge valve open. Although the ejector was a veritable steam eater it was the best means of priming we could get.

The other plant of this irrigation system was located about 19 miles from the river and took water out of the canal and discharged it into the irrigation ditches which supplied the rice fields. This plant was known as the upper lift and the pumps were built on the ground level, so there was scarcely any suction lift.

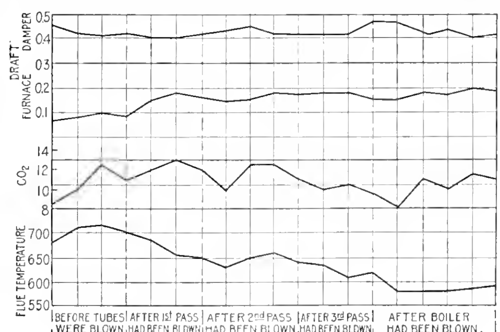
A. G. SOLOMON.

Chicago, Ill.

Soot Removal

In the Feb. 16 issue I read with interest the editorial "Soot," page 238.

Some time ago I made some observations on a horizontal, vertical-pass, water-tube boiler to determine the effect



EFFECT OF SOOT REMOVAL

of soot removal on the combustion and the temperature of the gases just after leaving the boiler.

It is our custom to blow the external surfaces of the tubes off with compressed air at about 100 lb. pressure. This is done daily except Sunday, which means that the boiler is accumulating soot and dust for 18 hours. The accompanying curves were plotted from data taken after each pass had been blown.

The draft pressures and condition of the fire were kept as nearly uniform as possible. The boiler is served by a front-feed inclined grate stoker. The temperature was taken at a point just after the gases left the last pass. The flue-gas sample was taken at the same place, and analyzed with an Orsat.

It will be interesting to note in these curves the peculiar relation between the draft pressures and CO_2.

H. R. BLESSING.

Philadelphia, Penn.

The editorial in a recent issue of POWER relative to the soot problem furnishes food for thought. Why is it that many power plants equipped with flow meters, CO_2 recorders, pyrometers, draft gages and other appliances designed to promote boiler efficiency still stick to ancient hit-or-miss methods of removing soot deposits from their boilers? In Germany power-plant operators realize that soot has about five times the heat-resisting qualities of asbestos, and most boilers have stationary soot-blowing equipment.

In this vicinity such installations are, comparatively speaking, few. The writer has in mind a plant where boiler tubes are blown twice a week. After this blowing, from 1½ to 2 tons of soot is removed from each boiler. The work is done by an attendant with a hand hose, and as such men are but human, and dragging a hot steam hose about a boiler room is anything but a pleasant job, more than one dust slide is skipped in the operation. The time saved between the opening of a couple of valves on a stationary equipment and the shifting about of a hand hose is so apparent that no comment need be made on it.

There have been numerous interesting and instructive discussions in POWER on flue-gas analysis, boiler settings and general power-plant practice, but this important subject of soot removal has not received much attention. Will not some who have equipment of this kind let us hear about it?

J. PRIEFER.

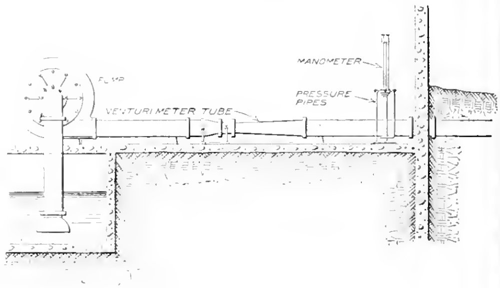
Brooklyn, N. Y.

Testing Small Centrifugal Pumps

I read with a great deal of interest the article by M. R. Blish in the Mar. 16 issue. Mr. Blish devotes considerable attention to the measurement of the discharge by means of weirs. I would like to suggest, however, that a much more convenient way of measuring the output from centrifugal pumps of either small or large size is by the use of a venturi meter tube with a mercury manometer. Such an arrangement is shown herewith. The tube is placed directly on the discharge from the pump and the pump performance may be tested under actual operating conditions if desired. This arrangement also has the advantage of being permanent if so desired, and a daily record of the pumpage may be kept. Any falling off in performance may be noted as soon as it occurs and the trouble corrected, if possible. If it is desired to test the pump under a greater range of heads than could be obtained at any particular time, the arrangement can be modified somewhat by placing a valve directly on the outlet cone and throttling it to obtain the head desired.

Mr. Blish in his article describes the use of a baffle plate to prevent serious velocity of approach of the water to the weir. With the Venturi tube this will not be required since the method of measurement by taking pressures at the upstream and throat or constricted portions of the tube is independent of the initial velocity of the flowing water.

The instrument is also considerably more convenient to read than the hook gage used with the weir. The manometer shown is a modification of the U-tube type and employs the same principle as the single-tube mercury barometer, the heavy pressure from the inlet of the meter tube being received upon the surface of the mercury in the



VENTURI TUBE AND MANOMETER FOR TESTING CENTRIFUGAL PUMPS

large well at the bottom of the instrument. The throat pressure is conducted to the top of the single glass tube. The scale may be graduated directly in gallons per minute. This type of instrument makes unnecessary the adjusting of the scale or rod and is particularly convenient in cases where it is desired to take frequent readings of suction and discharge heads, speed, temperature, etc., at frequent intervals with a small number of observers.

ALAN A. WOOD.

Providence, R. I.

Feeding Graphite to Boilers

The writer has experimented for several months to discover a satisfactory method of feeding graphite into stationary boilers and has found the following to be best. The feeder shown in Fig. 1 is used in plants where compressed air is available, and that in Fig. 2 where compressed air cannot be had.

Fig. 1 is composed of a 6-gal. galvanized-iron tank A with a loose-fitting lid on top; B is a 1-in. pipe extending through the bottom and three-fourths of the way to the top of the tank, with a tee on top to prevent the attendant from filling the pipe with graphite when he is charging the tank. A 1-in. gate valve or straight-way air-cock C is used as shown. A globe valve should never be used here on account of its liability to clog. A 1-in. line D should be connected to the suction of the feed pump. A sight-feed E, through which the attendant can see the amount of graphite being fed, is provided.

A ¼-in. line F should be connected to the city water line or to the discharge of the feed pump. A nozzle G is used with a ⅛-in. opening pointing to the bottom of the tank on a 45-deg. angle, to prevent graphite from settling to the bottom of the tank and keep it well mixed with water. A ½-in. valve *I* is used to drain the tank for recharging.

This feeder should be installed, so that the sight-feed is above the water line of the heater, and so that it will not fill with water.

To charge, close the valves *H* and *C*, open *I*, and drain water into the bucket. If this water contains graphite it

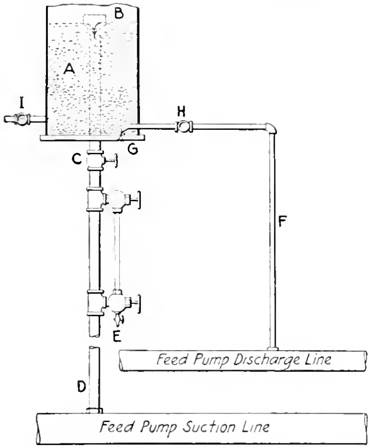


Fig. 1. Graphite Feeder Used Where Compressed Air Is Available

can be put back into the tank after charging. After putting in the required amount of graphite, pour the water drawn from the tank back into it, stirring the contents well to mix thoroughly, open valve *C* wide and regulate the feed with *H*.

Fig. 2 consists chiefly of a 150-gal. steel tank *A*, four ⅜-in. pipes *B* with $\frac{1}{32}$-in. holes drilled 2 in. apart on one

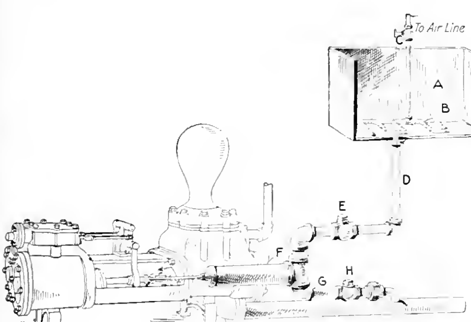


Fig. 2. Graphite Pump Operated by Boiler-Feed Pump

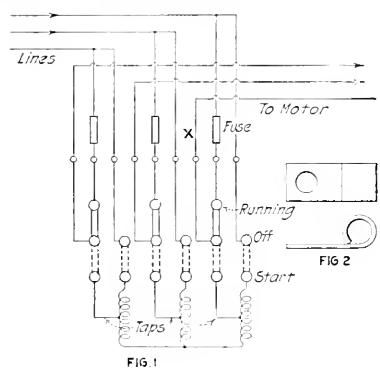
side and arranged in the tank so that the holes point downward, to keep the graphite from settling. A ½-in. air line *C* is connected to the compressed-air supply; *D* is a 1½-in. suction line; *E* 1½-in. swinging check valve; *F* a single-acting pump made of 2-in. brass pipe with a 2x1½x1-in. pipe tee on one end and the bonnet of a 2x2½-in. valve on the other. The piston head is made of brass, with two packing rings. The piston rod is made of ⅜-in. cold-rolled brass, with a permanent nut on the end of the rod and a sliding nut with a setscrew, so that the stroke of the pump can be adjusted to any desired length, regulating the amount of graphite fed with each stroke of the feed pump. The graphite pump is driven by the piston rod of the feed pump; *H* is a 1-in. discharge line, *G* is connected into the suction line of the feed and contains a 1-in. swing check valve.

C. N. Wiley.

Pittsburgh, Penn

Open-Circuited Compensator

The diagram represents the connections of a three-phase compensator for starting squirrel-cage induction motors. The leads from the line and to the motor are flexibly connected to the rocker-drum contacts marked "off." When the handle is in the position marked "start," the rocker makes the connections indicated by the double dotted lines; and with the handle in the running position, the connections are as indicated by the double full lines. In the starting position the line wires connect to the autotransformer terminals and the motor leads to the autotransformer taps, thereby applying approximately half voltage to the motor. In the running position the line wires are connected directly to the motor leads so



Compensator Connections

that the motor gets full voltage. The autotransformer is then entirely cut out.

It will be noted that the fuses are in circuit only on the running side. Inspection of the diagram also shows that the three wires that connect the cylinder contacts to the motor are in use irrespective of the position in which the starter may be; therefore, an open-circuit that affects operation in both positions is either local to these motor wires or to the line wires beyond the compensator connections.

An operator complained that his motor would not start from either side of the compensator, but would buzz, thereby indicating single-phase operation. Just above the compensator there was a small panel carrying the fuses and studs by means of which the compensator wires were connected to the line wires and to the fuses and motor wires. Connections were made with terminals similar to that indicated in Fig. 2, the ends of the wires being soldered into the sleeves and the eyes being slipped onto the studs and held there with nuts. With a bell the open circuit was finally located in the sleeve of the terminal wire marked A, Fig. 1. This had been caused by a layer of resin between the wire and the sleeve, the resin having been used as a soldering flux.

J. A. Horton.

Schenectady, N. Y.

Notes on Indicator Diagrams

In the Mar. 2 issue, A. R. Nottingham, under the above caption, discusses freak diagrams, particularly one that appeared in Power for Nov. 3, 1914. He states: "In the original diagram Fig. 1, the atmospheric line is $5\frac{1}{2}$ lb. too high. It should be where the dotted line is, though this does not affect the diagram so far as valve analysis is concerned."

Granting that the diagram was taken from the low-pressure cylinder, since neither the scale of the spring nor the vacuum line is given, how did Mr. Nottingham arrive at the conclusion that the atmospheric line is $5\frac{1}{2}$ lb. too high? As a matter of fact the diagram was claimed to have been taken from the high-pressure cylinder of a compound engine, and the atmospheric line should have been below the exhaust line, equal to the receiver pressure, which could not have been high in this case as most of the work was done by the high-pressure cylinder.

Victor Bonn.

New York City.

Boiler of a Traction Engine Exploded

The photographs reproduced show the general appearance of a traction engine after the boiler had exploded. The age of the boiler and the condition of the safety valve and steam gage are unknown to the writer. The shell was badly corroded and in one place had leaked and been patched, as may be seen at the lower part of Fig. 3. The weakest point seems to have been at the edge of the seam which joined the body to the firebox, where the sheet was corroded nearly through. There was but little scale on the surfaces.

The explosion occurred while the engine was standing on the public highway. The shell was carried 300 yards by the force of the explosion and the whistle was found one-quarter of a mile away. Fortunately, no one was hurt.

Claflin, Kan. J. J. Beeman.

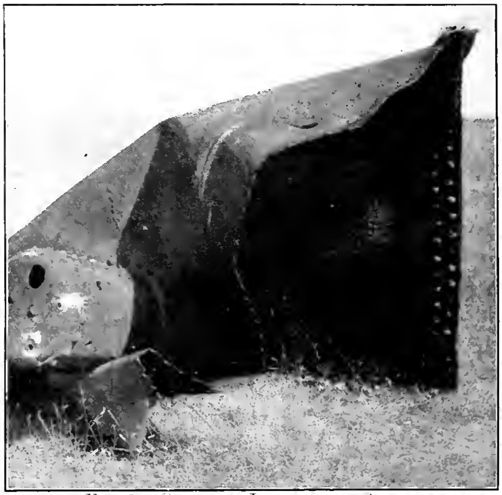


Fig. 3. Corroded Interior of Shell

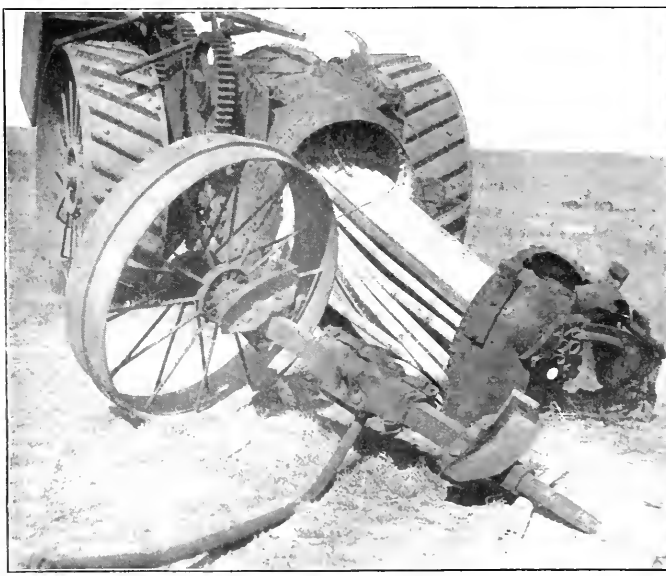


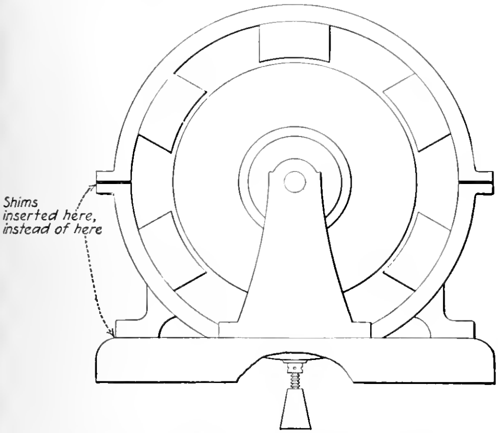
Fig. 1. Part of the Wreckage

Fig. 2. Smokebox End

Unequal Air Gap

Some time ago the writer had some experience with a generator failing to operate correctly, the cause of which may interest readers of POWER.

The machine was a 100-kw. 220-volt shunt-wound generator direct-connected to a gas engine, and operated various amusement devices and lights at a summer resort. The rated voltage would build up readily, but as soon as any load was connected, the voltage would fluctuate and the brushes spark badly, and no amount of shifting would remedy the trouble. The engine was checked for its rated speed as shown on the nameplate and found correct, and no appreciable variation was noted when load was applied.



FRAME SHOWING WHERE SHIMS WERE INSERTED

Upon inquiry it was found that the generator had just been installed, having been purchased second-hand. The field frame was split horizontally, and in order to facilitate handling and shipment to its present location the generator had been taken apart. As the men who had set it up were not experienced in handling electrical machinery, the natural conclusion was that possibly the field coils had been wrongly replaced or the brushes improperly spaced.

The fields were tested for polarity and found correct, and the spacing of the brushes was also gone over. It was while the armature winding was being examined to determine the neutral position of the brushes, that the unusual size of the air gap became apparent. Further examination of the frame revealed the presence of shims between the halves of the frame. The men who had done the erecting then explained that after they had placed the top half of the frame in position they noticed that there was just sufficient room beween the top of the armature and the bottom of the field coils to prevent rubbing while the armature was turned, whereas the space between the lower side of the armature and the bottom coils was quite liberal. So they had cut up some sheet iron and inserted it between the halves of the frame to make the air gap on the top of the armature equal that at the bottom. Here was the cause of the trouble.

A hoist was rigged from one of the roof trusses above the generator, the bolts holding the halves of the frame were taken out and the upper half was raised enough to remove the offending shims. The halves were then tightly bolted together and the air gap at the top and bottom carefully gaged.

The bolts holding the frame to the base were then loosened, and while the frame was steadied on all sides a jack, placed as shown in the sketch, raised it enough to insert sufficient shims to make the air gap equal at top and bottom. This completed, the engine was started again and the generator carried full load without further trouble.

The next morning one of the men found the shims that were sent with the machine and that should have been placed between the base and frame in the first place, securely tacked inside of the crates, out on the rubbish heap.

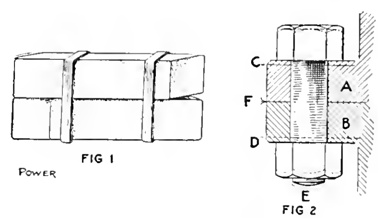
P. JUSTUS.

Cleveland, Ohio.

Holding Power of a Bolt

In deciding the size of a bolt to be used it should be assumed that it may be tightened by a helper who is instructed "to get it tight." To him this means that he is to put his whole weight on the wrench, if not extend the handle with a piece of pipe as long again.

To get a simple analogy to the action of a bolt clamping two pieces of metal together, take two erasers and fasten them together with a pair of light elastic bands, Fig. 1. Just as soon as a pull is exerted on the erasers they come apart enough to show light between them. The bands are more elastic, so they yielded more than the erasers were compressed by them in the first place. If very soft erasers and heavy bands are used, then quite a pull can be exerted on the erasers before any light will show, because they will go back to their original thickness before the same pull has stretched the elastics that much. This explains why it is necessary to have joint packings with some give to them to hold pressures. If the flanges and the bolts were of the same material it would be theoretically impossible to make up a tight joint without packing. Practically, it is feasible because the pressure of the bolts is hardest close to the bolt itself and the metal around the bolt hole is compressed more than that further away and more than the bolt is stretched.



RUBBER BAND AND BOLT ANALOGY

Fig. 2 shows this more clearly. The full lines show a bolt and nut drawn up just tight enough to touch the two flanges *A* and *B*. When the nut is drawn down hard the flanges are each compressed to the dotted lines *C* and *D* (exaggerated, of course) and the bolt itself is stretched to the line *E* at the same time. No matter how tightly the bolt is set up, it will continue to lengthen with additional pull. Now suppose that some pressure is brought to bear to separate the two flanges. It will stretch the bolt, but every particle that the bolt stretches, the flanges, which were compressed, tend to go back to their original thickness, so that there is a tight joint until the flanges have got back where they started from; then the opening is due to the additional stretch of the bolt. If an elastic packing is inserted at *F* it will also keep the joint tight until all the pressure on it due to the bolts is released. A corrugated copper gasket acts in the same way, the corrugations, which are flattened out under pressure, coming back when the pressure is relieved.

The longer the bolt, the more it will stretch under a given pull. An eight-inch bolt will stretch four times as much as a two-inch, but the packing has only so much give in it, hence the decided advantage in using short bolts where possible. The stretch also decreases as the square of the diameter increases. A one-inch bolt will hold four times as rigidly as a half-inch; not merely four times as much in pounds, but with only one-fourth the stretch for a given load.

There is, however, an advantage in a comparatively long bolt in places where it can act as a relief. If a cylinder is full of water the bolts may stretch enough to let it out without further injury, but, aside from this emergency, the use of short, thick bolts is good practice.

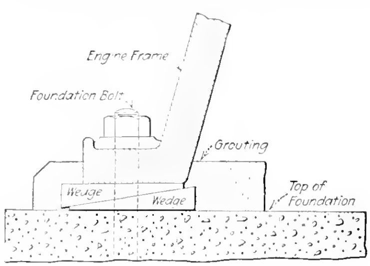
E. H. Fish.

Worcester, Mass.

Grouting under Heavy Machinery

To the articles under this title in the issue of Mar. 2, page 310, and Apr. 6, page 482, much can be added and still leave the matter of grouting unsettled in the minds of many.

My belief is that at least an inch should be left between the top of the foundation and the machine, and that the



Another System of Wedges

latter should be leveled by means of wedges placed as shown on the illustration, one set on each side of every foundation bolt. When the leveling is complete, every bolt should be tightened, so as to hold the machine tightly against the wedges. The latter should all be left permanently under the machine; and they will not slip if they are made of cast iron with the surface left rough.

The grouting material may be either neat cement, a mixture of sand and cement, sulphur, or lead. It should be poured so that it will cover the top of the foundation under the machine, and also cover the ends of the wedges on the outside, as shown. If a mixture of sand and cement is used it should be sufficiently thin to flow easily. On account of the cost, lead is seldom used, but it makes a very satisfactory job. Sulphur cannot be used under machines where the heat will be so great as to melt it.

J. E. Poche.

New Orleans, La.

The Boiler Inspector Confesses

I have read the lurid description of a boiler inspector's confession as printed on the Foreword page of the Mar. 9 Power. There is one item in it which causes me to wonder how it ever "got by" the editorial force.

It is this: "Investigation showed that the fireman had opened the blowoff valve, and before closing it rushed away on a signal from the engineer. Before he returned the explosion had happened. This knowledge relieved my mind, but I had learned my lesson."

It is needless to tell you that an explosion might possibly be caused by a sudden opening of a blowoff valve, but if the valve had been open for any length of time and left open, as in this case, the pressure would have been gradually lowered and the boiler would not have exploded.

Charles H. Garlick.

Pittsburgh, Penn.

[The chance of avoiding the rupture of a boiler depends on the pressure being reduced to nearly zero before the sheet or sheets become bursting hot. This may happen with the blowoff valve open. But if two or more boilers under pressure are connected to a common header and one bursts a sheet because of low water, a violent explosion would likely follow, blowoff open or not. There was more than one boiler in the plant mentioned in the foreword.—Editor.]

Pulsations in Steam Pipes

Correspondence published in the columns of Power has quite frequently referred to the methods which have been employed, with varying success, to cure pulsations of steam pipes. The remedy most commonly suggested is to place a receiver of moderate size in the steam pipe near the engine.

I have designed and had built several receivers of varying capacities, the smallest having a volume twice that of the cylinder which it supplied. Others were much larger, but not one was big enough to show any appreciable diminution in the vibrations in the line. However, there were advantages gained, which more than paid for the work and expense of putting them in, such as drier steam, higher initial pressure and a better steam distribution in the engine cylinder.

But in no instance did I succeed in stopping the vibrations entirely, without throttling the supply to the receiver until the flow in the steam pipe was comparatively steady.

I have seen just one receiver placed in the steam line to an engine that was large enough to stop the vibrations entirely, and that one, I am sorry to say, I did not and would not at that time dare to recommend.

Two boilers cross-connected by a drum riveted to the shells supplied steam to a 14x42-inch Corliss engine running 80 r.p.m. The four-inch steam pipe to the engine was about forty feet long, and vibrated in spite of anchors to such an extent that calking and reriveting the drum nozzles was a serious matter.

The solution of the problem was finally left to the engineer, who had the steam drum (which was 42 in. dia. by 14 ft. long) taken from the boilers, set vertically and connected direct to, and placed directly at the top of, the throttle valve of the engine. There was no further trouble from vibration or leaking rivets, and the initial pressure in the cylinder was six pounds higher than before the change was made.

That was the only receiver I ever saw large enough for the purpose intended, and the only one I know of that proved to be a complete solution of the pulsation nuisance.

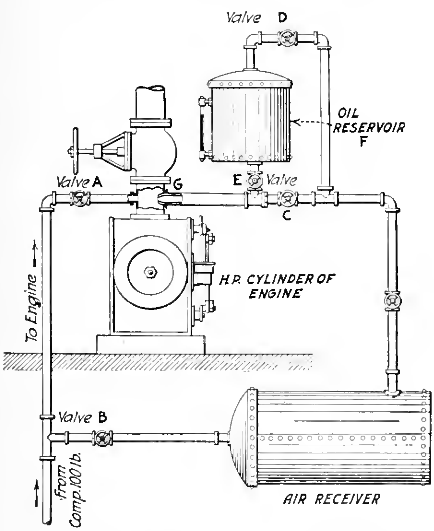
F. L. JOHNSON.

New York City.

Engine Operated with Compressed Air

The following scheme was worked out for turning over and lubricating a 15x32x36-in. compound engine, temporarily laid up, with compressed air instead of steam. Reference to the illustration will explain the piping arrangement.

All the fittings were in stock in the shop, and the job was done at little cost. To start up, fill reservoir *F* with



PIPING ARRANGEMENT FOR COMPRESSED AIR

light cylinder oil, open starting valve *A*, close receiver valve *B*, then open valves *C* and *D* slightly. Regulate the oil with valve *E*.

After the engine starts there is a fall of pressure in the line from the compressor on account of wire drawing in the small line. The receiver being closed off, the pressure does not drop rapidly and is higher at *C* than at *A*, thereby causing the atomized oil to flow through nozzle *G* into the engine.

C. H. REED.

East Chicago, Ind.

Telephone Receiver Connected to Calipers

A telephone receiver has been my constant friend about the plant for the past twelve years, for various uses, one of which is in connection with calipering, especially the work inside of engine cylinders, as in Fig. 1. The most convenient way is to have the two sides of the calipers insulated from each other. In Fig. 2, where the work in the lathe completes the circuit, causing a click in the receiver, an ordinary pair may be used with a cigarette paper between the work and one side of the calipers. This method is especially useful in aligning engines.

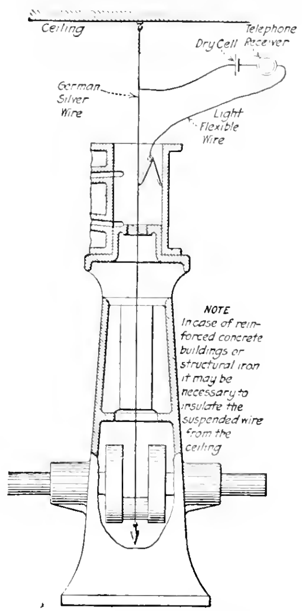


FIG. 1. ALIGNING AN ENGINE

Use a slender german-silver wire for the line, taking care that it is insulated from the ground if an ordinary caliper is used, or put a cigarette paper next to the cylinder wall; then, with one side of the circuit connected to the aligning wire and the other to the calipers, a circuit will be completed when the two come in

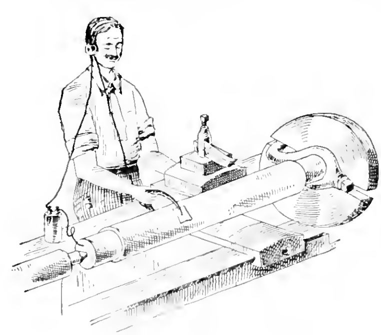


FIG. 2. GAGING OUTSIDE WORK

contact. A click will be heard when a contact is so slight that it cannot be seen or felt. Care should be taken not to use too much battery power, as it is annoying to the ear.

AMOS J. CARR

Fort McKinley, Me.

Heating Surface of Superheaters—Experiments prove that 5 B.t.u. per sq.ft. of heating surface will be transferred to steam for each degree of difference between it and the gases.

Easy Calculation of Steam Coal Required by Power Plants

By R. E. Horton*

The writer and his assistants have frequent need to calculate the cost of coal required by actual or hypothetical steam plants under comparison with proposed hydraulic stations. After a few laborious repetitions of computations going back to fundamental factors, the office practice was standardized in the interest of general economy and capacity. A table prepared is here given as of possible interest to others.

Computations were carried through and tabulated for the yearly coal consumption in tons at a rate of 1 lb. per hp.-hr. under various conditions. Now it is only necessary to ascertain or estimate and combine (1) the simplest unit coal consumption (per horsepower-hour, including allowance for shrinkage and waste if any); (2) the average horsepower in use when running; (3) the allowance for banking; (4) the hours' use per day, and days per year.

FACTORS FOR CALCULATING AMOUNT OF STEAM COAL REQUIRED PER HORSEPOWER-YEAR

	Gross Tons, 2240 Lb.		Net Tons, 2000 Lb.	
Method of Operation	310 Days	365 Days	310 Days	365 Days
10 hr. per day, no banking.......	1.38	1.63	1.55	1.83
10 hr. per day plus ⅓ for banking	1.84	2.17	2.07	2.43
12 hr. per day, no banking.......	1.65	1.96	1.86	2.19
12 hr. per day plus ⅓ for banking	2.21	2.61	2.48	2.92
24 hr. per day, no banking.......	3.32	3.91	3.72	4.38

For example: A plant runs 10 hr. per day and 310 days per year, produces 500 hp. average, uses 2½ lb. per hp.-hr. of steam coal, has ⅓ allowance for banking; coal costs $3.50 per gross ton. From the table, the proper unit consumption per horsepower year is 1.84 gross tons.

Then,

$$2.5 \times 1.84 \times 500 \times \$3.50 = \$7735 \text{ annual cost.}$$

Sometimes it is necessary to know the tons of ash that will have to be disposed of each year; then it is necessary only to substitute the decimal percentage of ash in the coal for the price per ton. For 15% ash the foregoing case shows

$$2.5 \times 1.84 \times 500 \times 0.15 = 345 \text{ gross tons.}$$

—"Engineering News."

Aneroid Calorimeter†

By H. C. Dickinson and N. S. Osborne

The term aneroid calorimeter is applied to a type of instrument in which equalization of temperature is secured by means of the thermal conductivity of copper instead of by the convection of a stirred liquid. The calorimeter, consisting of a thick-walled copper cylindrical vessel in the walls of which are embedded a coil of resistance wire to supply heat electrically and a platinum resistance coil for use as a thermometer, has been found useful over a wide range of temperatures and is applicable to a variety of problems.

For use at low temperatures the device is mounted in a jacket surrounded by a bath of gasoline, the temperature of which can be controlled thermostatically to within a few thousandths of a degree at any temperature between —55 and +40° C. or can be changed rapidly in order to keep it the same as that of the calorimeter when heat is being supplied to the latter.

Differences in temperature between the surface of the calorimeter and that of the jacket are measured by means of multiple thermocouples which have 10 junctions distributed over the surface of each, thus making it possible to apply accurate corrections for thermal leakage between the calorimeter and the jacket even when the temperatures of both are changing rapidly.

The platinum resistance coil (for use as a thermometer) embedded in the calorimeter shows slight irregularities in its behavior, probably due to the difference in expansion between the platinum and the copper which surrounds it. Uncertainties on this account, while in general negligible, can be avoided by measuring the temperature of the outer bath with a standard resistance thermometer, using the thermocouples to measure the small difference, usually not more than a few thousandths of a degree, between the calorimeter and the jacket. The thermometer could probably be improved by changing the construction.

Results of a series of experiments (page 565, Apr. 27, 1915, issue) give the constants of the resistance thermometer and the heat capacity of the calorimeter, including a tin-lined cell for use in determining the specific heat of ice and water and the latent heat of fusion of ice.

A series of check experiments on the specific heat of water shows the order of reproducibility of results which can be obtained with this calorimeter to be 1 part in 2000. Measurements made at temperatures between 0 and 40° C. gave results which agree to within the limits of experimental accuracy with the unpublished results of a long series of experiments made in the usual form of stirred-water calorimeter. The results are also in satisfactory agreement with the most probable values deducible from the data of the most careful investigations published by other observers.

*Consulting Hydraulic Engineer, 57 No. Pine Ave., Albany, N. Y.

†Abstract of a paper issued by the Bureau of Standards, Department of Commerce, Washington, D. C.

Influence of Indicator Connecting Pipes*

By Thomas W. Morley

It is usually stated that one of the conditions for accuracy in taking engine-indicator diagrams is that the connection between the engine and the indicator should be short, direct and of ample bore. The effect of bends, undue restrictions and excessive length of indicator pipes would be to delay the pressure change at the indicator, and hence to cause errors in the diagram. This resistance can best be investigated experimentally, and the author, having been able to find only very meager evidence as to the errors introduced by various connections, has conducted experiments to find out whether the arrangements commonly used are responsible for measurable errors.

A small steam engine was used to produce cycles of pressure change typical of those occurring in steam-engine practice. The engine employed was vertical, with a 6½-in. cylinder, 6-in. stroke, and ordinary slide-valve and link-motion valve gear. The cutoff was kept at about 0.4 of the stroke throughout the experiments.

Alternative indicator connections, long and short (Fig. 1), were arranged, and pairs of diagrams taken through these connections were compared. A and B denote the points at

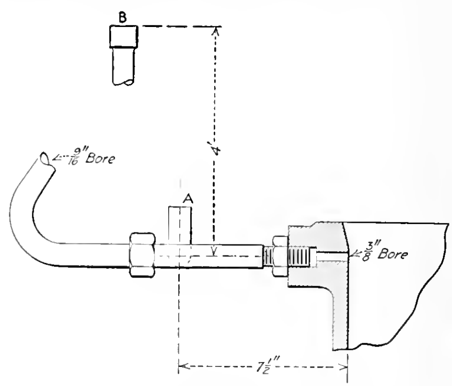


Fig. 1. Alternative Indicator Connections

which the indicator cocks were coupled. The upper end of the long pipe was, of course, suitably fixed.

At first, two similar indicators were placed at A and B, but it was found that, although of the same make, they did not give diagrams that admitted of convenient comparison. In subsequent experiments only one was used, care being taken that no change in the steam pressure or engine speed took place while the indicator was transferred from one position to the other.

Before the arrangement shown in Fig. 1 was adopted, preliminary experiments were made, using next the engine a two-way cock connection. The length between the upper and the lower positions was the same as in Fig. 1.

*From a paper presented before the Institution of Engineers and Shipbuilders in Scotland.

The diagrams thus obtained differed widely. For example, at 325 r.p.m. and a maximum pressure of 50 lb. per sq.in., the mean effective pressures were 36.4 for the lower and 20.4 lb. per sq.in. for the upper diagram. Even at 80 r.p.m. the difference was about 30 per cent. This was caused chiefly by the small bore ($\frac{3}{16}$ in.) of the two-way cock. After it was bored out to ⅜ in. the difference of the diagrams fell to 4 per cent. at about 300 r.p.m. The use of the two-way cock still had the drawback that, when the upper indicator was in use, the pipe connection formed an appreciable addition to the cylinder clearance volume. This in itself might affect the cycle of pressure change in the engine and so account for the difference in the diagrams.

In the final arrangement, shown in Fig. 1, the pipe connections to each indicator cock were constantly open to the cylinder, so that the pressures in the whole system were always unaffected. Also, except for the short ⅜-in. channel at the cylinder wall, the connections to the indicators were of uniform bore. Under these conditions a number of tests were made with gage pressure up to 75 lb. per sq.in., and speeds up to 280 r.p.m. Fig. 2 shows a typical pair of diagrams. The differences between them are so small that they would be concealed if one had been superposed on the other. The chief visible difference in the diagrams was that those taken with the long connection showed more waviness of outline, due, no doubt, to the oscillations set up in the long pipe.

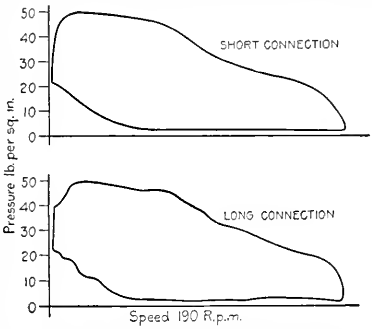


FIG. 2. INDICATOR DIAGRAMS FROM ALTERNATIVE CONNECTIONS

The following table shows the results of the experiments:

Speed of Engine R.p.m.	Maximum Pressure (from Diagram) Lb. per Sq.In.	Mean Effective Pressure Long Connection P_1 Lb. per Sq.In.	Mean Effective Pressure Short Connection P_2 Lb. per Sq.In.	Difference $P_1—P_2$ Lb. per Sq.In.	Difference per Cent.
150	48	27.32	27.48	—0.16	—0.6
153	29	15.46	15.46	...	...
178	76	49.44	49.44	...	...
182	73	49.9	49.9	...	...
190	25	13.15	13.15	...	...
190	31	17.75	17.6	+0.15	+0.85
195	40	24.4	24.0	+0.4	+1.6
190	48	29.65	29.9	—0.25	—0.85
195	55	35.1	35.1	...	...
190	60	38.2	38.2	...	...
190	60	38.6	38.2	+0.4	+1.1
190	68	44.9	44.9	...	...
272	25.5	12.24	12.44	—0.2	—1.6
240	70	43.2	42.8	+0.4	+0.95
254	66	42.12	43.02	—0.9	—2.1
284	38.5	22.1	21.5	+0.6	+2.8
280	42	24.8	25.2	—0.4	—1.6
275	47	27.7	28.1	—0.4	—1.4
280	53	32.6	32.3	+0.3	+0.95
270	62	37.9	37.8	+0.1	+0.25

The general conclusion to be drawn from the experiments is that the influence of the connecting pipes does not subject indicator diagrams to any appreciable error, except in abnormal cases. The difference of the mean effective pressures was always small, in only two cases exceeding 2 per cent.; and was in fact within the limit of probable error of the indicator itself.

In the discussion following the delivery of the paper the conclusions reached were questioned because the connection at A in Fig 1 had two bends and the long pipe was in communication with the cylinder while the indicator at A was in use. In answer to the latter objection the author explained that the arrangement used satisfied the real object of the experiments, which was to compare the influence of long and short pipes connected to a point at which a certain pressure cycle took place. The indicator at A need not give a faithful record of the cylinder pressures. Coming now to the other objection, the indicators at A and B were separated from the point where there was a constant cycle of pressures by a bend and a short pipe in one case, and in the other by an easier bend and a long pipe. Experiments other than those described in the paper had been made on this engine with connections of about the same length as that to A, but with a different number of bends. No appreciable difference in the results had been observed. It was therefore considered that any difference in the influence of the two connections would be due to their lengths alone and would not be obscured by the bends.

Why Should Such Things Be?

A leading machinery firm in Bombay expressed the opinion that American boilers could not be successful in India, because of the steel used not being of the right quality as required by government testers. American manufacturers do not follow Indian specifications, and offer openhearth steel instead of basic. The market in India is for boilers built for high pressure. The steel should not be too hard, but somewhat flexible. German boilers have sold well in India because they are made of steel that expands well. Nearly all boilers used in India are of Lancashire type. This firm states that it imported a boiler from the United States about 15 years ago and still has it on hand, being unable to sell it. Boilers in India are mostly used for cotton mills, ginning factories, etc. —Henry D. Baker, U. S. Consul, Bombay.

Blowout of Turbine Exhaust Casing

Although the local newspapers reported that an accident had taken place on Mar. 31 at the plant of the Boston Manufacturing Co., Waltham, Mass., the causes given varied from a blowout of the cylinder head of a turbine engine to a turbine explosion. Perhaps the most comprehensive was the statement that the explosion in a 750-kw. engine blew up the generator and badly damaged the boiler.

Further investigation has shown that at 5:45 p.m. on the date mentioned, the exhaust casing on a 750-kw. G-E Curtis turbine was blown to pieces, hurling through a window the engineer, William Finley, who was standing near. Outside of the turbine the damage was confined to the wrecking of the engine-room windows and the dislodging of a few bricks by pieces of the casing blown against them.

The accident is said to have been caused by the closing of the exhaust valve before the throttle was closed, the relief valve provided for such emergencies failing to operate.

PERSONALS

Messrs. John S. Griggs, Jr., and David Moffat Meyers have consolidated their consulting practices with offices at 110 West Fortieth St., New York City. Mr. Griggs was a member of the consulting firm of Griggs & Holbrook, New York, and has been in practice for the past twenty years. Mr. Meyers, who is the author of the recently published book, "Preventing Losses in Factory Power Plants," was formerly mechanical engineer for the United States Leather Co. The firm will specialize in mechanical and electrical propositions for industrial and other installations.

C. P. Poole, chief engineer of the Department of Mechanical Engineering of the City of Atlanta, Ga., has been appointed a member of the International Jury of Award in the Department of Machinery of the Panama International Exposition. Mr. Poole, who will be remembered as one of the editors of "Power," has been for some time in charge of what was known as the Department of Smoke and Gas Inspection of Atlanta, and under his direction the activities of the department have broadened out so as to make necessary the reorganization indicated by the new title.

ENGINEERING AFFAIRS

Stationary Engineers' Day at the Fair—The management of the Panama-Pacific Exposition has designated Saturday, May 29, as Stationary Engineers' Day. This will enable the delegates and guests of the California State Association of the N. A. S. E. to enjoy that day at the Fair, since the annual convention of this association will be held in San Francisco on May 27 and 28.

The Fifteenth Annual Summer Session of the College of Engineering of the University of Wisconsin will be held at Madison during the six weeks' period beginning June 21. Special courses will be given in electrical, steam and hydraulic engineering, gas engines, machine design, mechanical drawing, mechanics, shopwork and surveying. Further information may be obtained from F. E. Turneaure, Dean, Madison, Wis.

The International Engineering Congress which is to be held in San Francisco in September will issue in Vol. IV of its transactions the papers presented on "Railways and Railway Engineering." The field treated will cover the relation of railways to social development, present status of railways, economic factors governing building of new lines, location, physical characteristics of road including track and roadbed, bridges, tunnels, terminals, construction methods, signals, road equipment, including motive power other than electric, rolling stock, floating equipment, and electric motive power. W. A. Cattell, 417 Foxcroft Bldg., San Francisco, secretary of the Congress, will furnish particulars regarding membership and the securing of the transactions to those interested. These transactions will include nine or ten volumes, covering the various fields of engineering.

NEW PUBLICATIONS

MECHANICAL WORLD POCKETBOOK, twenty-eighth issue. Norman Remington Co., Baltimore, Md., American agents. Size, 4x6 inches; 330 pages. Price, 50 cents.

Besides the usual data given in previous editions of this well-known low-priced handbook, this issue contains an extended and rewritten section on toothed gearing and a more lengthy section dealing with structural iron and steel work. Also, new sections on limit gages and on the cost of power have been added.

ADVANCED ELECTRICITY AND MAGNETISM. By W. S. Franklin and Barry MacNutt. Published by the Macmillan Co., New York. Cloth, 5½x8½ inches; 300 pages; 217 illustrations. Price, $2.

This book is designed for students in colleges and technical schools. The subject matter deals with the elementary theory of magnetism and with advanced principles of the magnetic measurement of current, electromagnetic induction, electrostatics and electric waves. An outline is given of the electron theory and of its application to the vacuum tube and the electric arc. The historical development of the theory is entirely, and the mathematical largely, omitted, the treatment being confined to concrete presentations of a few principles. A number of problems (with answers) are given at the ends of the chapters.

HEATING AND VENTILATING BUILDINGS. By R. C. Carpenter. Published by John Wiley & Sons, Inc., New York. Cloth, 6x9 in.; 598 pages; 290 illustrations. $3.50.

Professor Carpenter's well-known treatise, now published in its sixth edition, is a manual for heating engineers and architects. It gives general methods of design and construction as well as the elementary principles applying to heating and ventilating apparatus. While the previous edition has been rearranged to a considerable extent, the additions in the sixth edition consist mainly of a chapter on air conditioning and of abstracts of heating and ventilating laws. The determination and regulation of humidity and the methods of purifying air are broadly described. Abstracts of the laws relating to the heating and ventilation of schoolhouses and public buildings in 17 states are given. The book has the disadvantages common to most technical treatises in which an attempt is made to keep them up to date by publishing new editions. Even with the best of intentions it is difficult to thoroughly revise an old book. This is evidenced in the present instance by the many results of tests and investigations made in the late 80's and early 90's. This material was adequate when the book was first published in 1895, but at the present time, although perhaps of historical value, is surely not indicative of the state of the industry. Another disadvantage is the difficulty in adding new material without affecting the unity of the original treatment. For example the present volume has two sets of sections numbered from 56 to 72 inclusive. Of course this is caused by carelessness in revision, but it goes to show a minor trouble experienced in forcing the original text to assume a new and different form.

TRADE CATALOGS

E. Keeler Co., Williamsport, Penn. Catalog. Return tubular boilers. Illustrated, 46 pp., 7½x10½ in.

Armstrong Cork Co., Pittsburgh, Penn. Pamphlet. "Good Furnaces Made Better." Illustrated, 20 pp., 3½x6 in.

The DuBois Machine Shop, 118 Hudson Ave., Albany, N. Y. Booklet. Randerson automatic piston ring. Illustrated, 3x6 in.

Otis Elevator Co., Eleventh Ave. and 26th St., New York. Catalog. Gravity spiral conveyors. Illustrated, 56 pp., 6x9 in.

B. F. Sturtevant Co., Hyde Park, Boston, Mass. Bulletin No. 214. Turbo-undergrate blower. Illustrated, 24 pp., 6½x9 in.

Allis-Chalmers Mfg. Co., Milwaukee, Wis. Bulletin No. 1532. Allis-Chalmers oil engines, Diesel type. Illustrated, 16 pp., 8x10½ in.

The D. T. Williams Valve Co., Cincinnati, Ohio. Catalog No. 10. Valves, steam cocks, water gages, lubricators, steam traps, etc. Illustrated, 320 pp., 5½x8 in.

American Blower Co., Detroit, Mich. Bulletin No. 24—Series 4. Sirocco heating, ventilating, cooling and purifying system. Illustrated, 32 pp., 8½x11 in.

Gas Engine & Power Co. and Chas. L. Seabury & Co., Cons., Morris Heights, N. Y. Catalog No. 10. Seabury safety water tube boilers. Illustrated, 46 pp., 6x9 in.

Richardson-Phenix Co., Milwaukee, Wis. Bulletin No. 10. Peterson power plant oil filter and accessory apparatus for central oiling systems. Illustrated, 32 pp., 8½x11 in.

General Electric Co., Schenectady, N. Y. Bulletin No. 48,904. Electric arc welding. Illustrated, 10 pp., 8x10½ in. Bulletin No. 48,905. Arc welding apparatus. Illustrated, 6 pp., 8x10½ in.

Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin No. 101. Sprays for Cooling Condensing Water. Illustrated, 14 pp., 6x9 in. Bulletin No. 151. Washing and Cooling Air for Steam Turbine Generators. Illustrated, 8 pp., 6x9 in.

POWER

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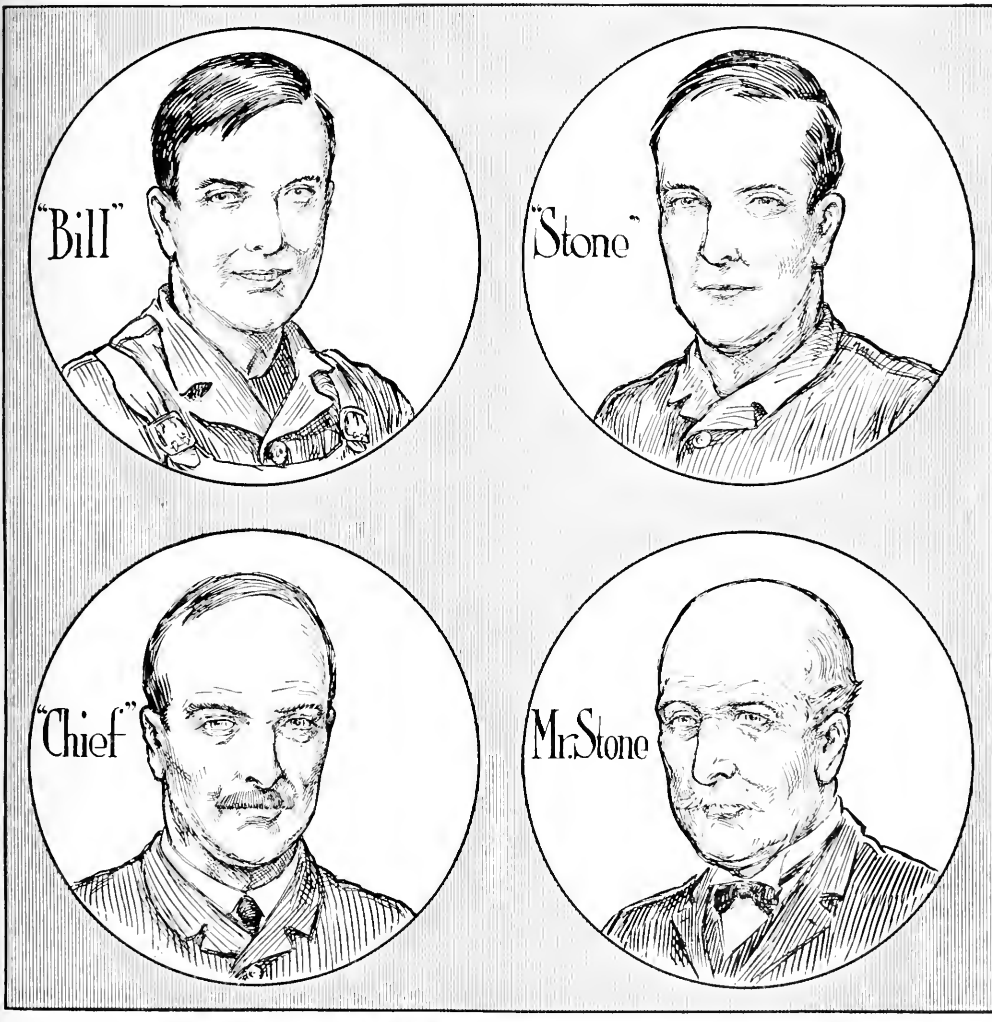


Milestones

Steam Turbines--Their Principles and Operation*

By Charles H. Bromley

SYNOPSIS—The lecture is intended for operating men. It explains in simple words and diagram how a turbine makes use of the energy in the steam, what impulse and reaction are as applied to turbines, what staging is and why it is necessary; tells in a general way what to do when starting and stopping, and emphasizes the importance of careful attention to the oiling system and the blade clearances.

To understand the turbine it is essential that one be acquainted with the forms of energy of which it makes use. Energy is of two kinds, potential and kinetic. The former is rest energy, or energy capable of manifesting itself by reason of position, as the weight of a pile driver before it is released to descend, as steam under pressure, confined and ready to move on being released, or as a spring compressed or elongated. Things have potential energy by reason of their position or by the state of arrangement of their molecules. Kinetic energy is energy of motion, as the energy in a falling weight, a moving train, a jet of water or steam. When kinetic energy is mentioned velocity is always implied.

The reciprocating engine uses the potential energy in the steam, for the energy is given up by the steam as it expands, pushing the piston ahead of it. The potential energy is converted directly into mechanical work. A turbine changes the potential energy into kinetic before it does work with the steam. It may make the change complete before the steam enters the moving parts of the turbine, or it may make it in installments—in stages.

Difference between Impulse and Reaction

This brings us to the subject of impulse and reaction, that is, to the two ways in which the energy is extracted from the steam at the turbine blades. Impulse action, when related to turbines, means to force, to impel, by impact, as when you wash the floor with water from a hose. The blow, the impact, with which the water strikes the dirt drives it ahead. In an impulse turbine the steam does the same thing to the wheel. Examples of impulse and reaction are shown in Fig. 1. A good illustration of reaction is the common whirling lawn sprinkler shown. The water under pressure flows from the nozzles, causing them to move in a direction opposite that taken by the water. Reaction as applied to a turbine wheel may be explained as a backward push as the steam passing through the nozzles reduces its pressure. The wheels of reaction turbines have blades that form nozzles, and the pressure at the inlet side is greater than that at the outlet. This pressure difference in the wheel is what causes it to revolve. In an impulse turbine the pressure is the same on both sides of the wheel. The two kinds of blading, impulse and reaction, are shown in Fig. 2.

*From a lecture before the Modern Science Club, Brooklyn, N. Y.

Keeping in mind the two forms of energy, it is well now to understand what is meant by staging as applied to turbines. One of the definitions of stage given in Webster's Dictionary admirably suits our needs:

Stage: "A distance between two places of rest on a road; hence, a degree of advance in a journey."

Steam at high pressure enters the turbine, passes through it and comes out with most of its energy extracted. The steam is on a journey, the turbine is the road and the intervals between stages are the places of rest on the way. If the steam passes through the turbine from the high to the low pressure all at once, if it does not rest, as it were, between the two points, if there is but one distance between the beginning and the end of the journey (expansion), then that turbine is a single-stage machine. If the steam rests more than once on the way, then the turbine through which it passes is a multi-stage machine.

In Fig. 3, left, the pressure due to the total head is applied to the wheel. It is a single-stage machine. At the right the total head is divided into four parts. The machine is a multi-stage one. Each wheel has but one-fourth of the total pressure applied to it. The velocity of the water at the nozzles is less in the multi-stage than in the single-stage machine and therefore permits of running the wheels slower, although about the same amount of energy is taken out of the jets in both cases. The advantages of dividing the pressure or velocity drop in this way in steam turbines will be taken up presently. A stage in a turbine may also be considered as a compartment for a wheel where the steam decreases either its pressure or velocity, as shown in Fig. 4.

By properly graduating the cross-section of a nozzle you can expand steam from one pressure to another, making the drop between inlet and outlet as much as desired. Such nozzles form the communicating passages between the stationary and moving blades or between the stages or compartments of a turbine. It is in this way that the pressure and velocity are controlled in the wheels and the stages, or wheel compartments.

Single- and Multi-Staging

Primarily, it is the great amount of energy liberated by the expansion of a comparatively small weight of steam that makes staging in turbines necessary. A pound (weight) of steam at 150 lb. pressure expanded in a perfect nozzle to 1 lb. absolute (28 in. vacuum) gives up 325 B.t.u., which is equivalent to $325 \times 778 = 252{,}850$ ft.-lb. of energy.

In expanding between these two pressures in one jump the steam would attain a velocity of a little over 4000 ft. per second, or more than 2700 miles an hour. Nearly all the energy (potential) that was in the steam before its expansion is present after expansion in the kinetic (velocity) form. To convert the kinetic into mechanical energy the steam must be brought to rest by the turbine wheel or rotor.

In an impulse turbine expansion of the steam occurs only in the nozzles, or stationary blades, and in a single-

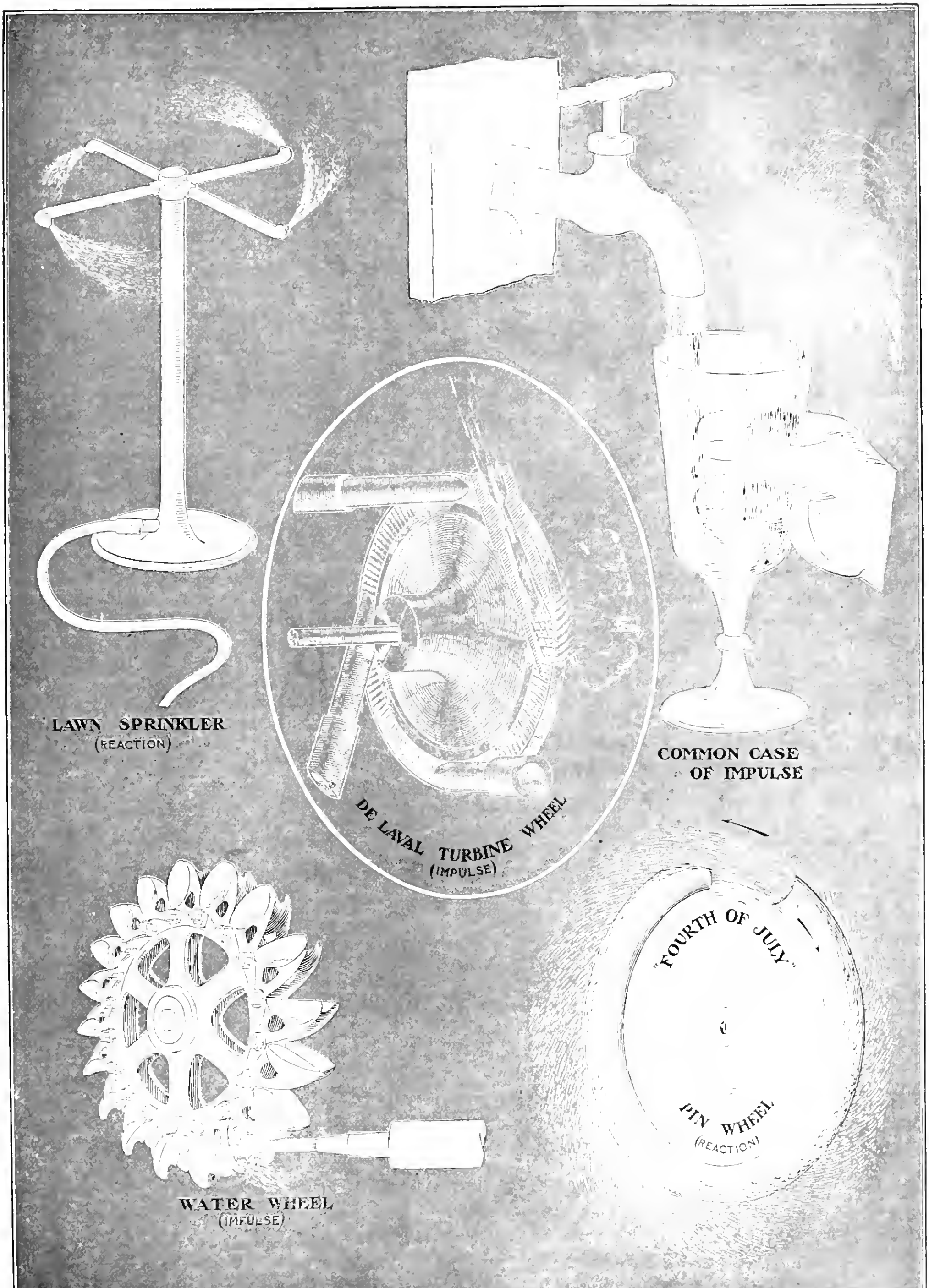


FIG. 1. EXAMPLES OF IMPULSE AND REACTION

stage machine, like the De Laval, Fig. 1, for example, the steam is fully expanded in the nozzles and therefore it strikes the wheel at the enormous velocity of about 4000 ft. per sec.

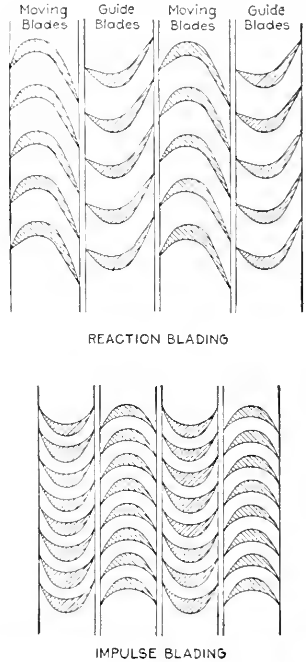
If the glass in Fig. 4 were moved in the same direction as the jet, or stream, of water and at one-half the velocity of the stream, the water would just flow over the side of the glass and all the energy in the jet would be extracted. To bring the steam to rest the wheel must run at half the speed of the steam jet, or, for the single-wheel turbine the peripheral speed of the wheel must be 2000 ft. per sec. Under these conditions the steam would leave the wheel with just enough velocity to force itself away from it. To produce this effect, i.e., to get the steam to leave the bucket with no velocity, means using an enormous wheel if a fairly low number of revolutions per minute is desired, or, if a small wheel is used it must run at an extremely high speed. Mechanical difficulties do not permit of obtaining slow wheel speeds, for the wheel would be too large (64 ft. diameter for 600 r.p.m.), so small wheels running as high as 30,000 r.p.m. are used in the small-sized single-stage De Laval machines. Gears are used to reduce the speed to accommodate the driven machine. About 500 hp. is the capacity limit commercially for a single-stage turbine.

Suppose all the velocity were not extracted by the wheel. Then there would still be energy in the steam which might be applied to another wheel and from the second to a third and then to a fourth, all on the same shaft; and so on until the pressure and velocity, and therefore the energy, were zero. With a suitable number and arrangement of wheels, nozzles and diaphragms (partitions forming the stage compartments) the pressure and velocity changes through the turbine may be controlled as desired. On page 630 the diagrams, Figs. 5, 6, 7, 8, and 9, show the different methods of extracting the energy from the steam. The page will make a good insert for your notebook. The tendency here and abroad is toward the wider adoption of the "composite" design, i.e., velocity staging in the high-pressure end and pressure staging in the low-pressure end. A good illustration of this design is shown in Fig. 9. Note the large drop in pressure in the impulse, or velocity, chamber.

For a simple and entertaining explanation of steam speeds and bucket speeds the reader is referred to the article by F. R. Low in last week's issue.

Starting and Stopping

When steam is turned into an engine it fills the space back of the piston and in some cases the whole cylinder, warming it uniformly and therefore minimizing strains due to expansion. In most large turbines steam would not be admitted around the whole circumference of the rotor when the turbine was standing still unless special "warming pipes" were provided, as they sometimes are. So, to warm a turbine, large or small, it is always best to have all drains open and admit steam quickly enough to revolve the turbine, letting it warm while running. If allowed to stand still with warming steam on, the steam will flow along through the blading in a path, thus creating unequal expansion of, and imposing objectionable strains in, the rotor and casing. If the sealing-gland water is admitted under pressure created by a pump, a tank or from the city mains the turbine may be started condensing. If the gland-seal water pressure is created by an impeller on the shaft whose speed is that of the rotor, and there is no means of sealing, then it is best to start noncondensing, putting the condenser in service slowly after the turbine has attained normal speed. In this way excessive amounts of air are not carried into the machine. Turbines using steam-sealed carbon-ring packing may be started condensing. It is



Cross-Sections of Turbine Blades

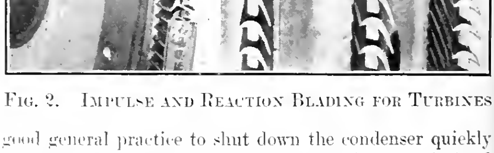


Fig. 2. Impulse and Reaction Blading for Turbines

good general practice to shut down the condenser quickly when stopping a turbine, for with some designs of gland seals cold air would be drawn in when the steam was shut off the machine if the condenser were left running, exposing the rotor to distortion, which is objectionable.

Turbine Lubrication

Lubricating oil for large turbines, vertical or horizontal, is supplied under pressure, the oil being forced by at least two pumps, one driven by the turbine shaft, the other a small, usually duplex, steam-driven pump. The latter should be started before the turbine is turned over to insure good circulation for starting. When the turbine is up to about normal speed the shaft-driven pump goes into useful service and the steam-driven one may be stopped. When shutting down, start the steam-driven pump and let it run until the turbine stops. Sometimes an elevated tank is used for supplying oil for starting and stopping. The aim always should be to have the oil and the oil-cooling water circulating before starting, and continue flowing without cessation until the machine is at a standstill. This is important.

The importance of a continuous oil supply to the bearings of a turbine is much greater than for a reciprocating engine. This is because of the small clearances between the stationary and rotating parts, because the speed is much greater, and because the bearings are near the high-temperature parts of the machine. All of these conditions make a hot bearing much to be feared. Should the babbitt or white metal in the bearings reach the melting point and become plastic, the rotor will drop, owing to its weight, and if not stopped in time many blades may be ripped off, and if it is a single-flow Parsons-type machine the dummy pistons and rings will be seriously damaged. The oil circulation system—the reservoir, the pumps, the filter,

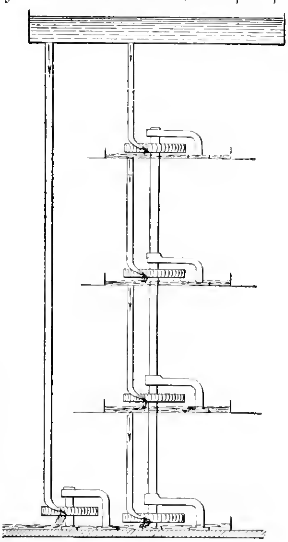


FIG. 3. INSTEAD OF APPLYING THE TOTAL PRESSURE ON ONE WHEEL (ONE STAGE), THE MULTI-STAGE MACHINE USES MORE THAN ONE WHEEL, APPLYING ONLY PART OF THE TOTAL PRESSURE ON EACH

the cooler, the pipe lines and the oil grooves—must be given the most thorough attention.

As the oil consumption of turbines is low on account of no oil getting in contact with steam or condensate, and because of the circulation system, it is good engineering to use a high-grade mineral oil, free from acids, thickeners, tarry, slimy and saponifiable substances. The General Electric Co. recommends that the flash-point, open-cup test, should be below 331 deg. F. and that the viscosity should not be more than 228 sec. at 10 deg. C. (101 F.), as shown by a Saybold viscosimeter, which is the kind used by the Standard Oil Co.

Good general instructions for starting are: Have all glands sealed at about 5 to 10 lb. pressure; the atmospheric or free exhaust valve is usually water-sealed. Have it sealed. Have the oil circulating through the bearings. If the turbine is a Curtis vertical, start the step-bearing and valve-gear pumps and maintain the necessary pres-

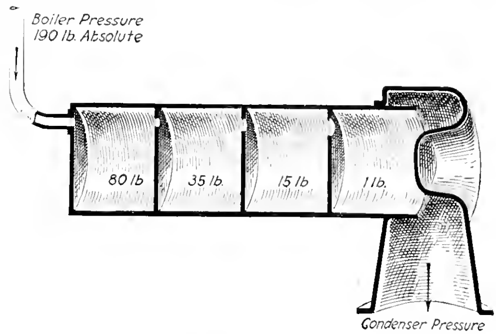


FIG. 4. TURBINE STAGING CONCEIVED OF AS COMPARTMENTS

Note that the openings between compartments increase from the high- to the low-pressure end to pass the increasing volume of steam.

sure—750 to 1500 lb. on the bearing, depending on the size of the turbine. Now start the dry-air pump, the hot-well pump and the circulating pump. Usually, there is a pipe leading from the condenser to the top of the circulating pump. Open the valve in this line (priming line), as it allows air to be exhausted from the pump and suction and assists the pump in picking up its water. Slowly bring all pumps up to speed. If there are drains for the different stages of the turbine, open them. Now start the main turbine slowly, increasing the speed and letting the governor get control.

Look around to make sure that the oil and water circulation is good, that the circulating-water pressure and step-bearing oil or water pressure are right, and that the governor has control. Next close the circulating-pump priming valve. Now put on the load. If there are steam-sealed glands, shut off the steam to the high-pressure packing, for the pressure in the first stage prevents air getting in. It may be necessary to regulate the pressure on the low-pressure packing. Now close the drains of the stages. The gear may then be oiled. The main turbine may vibrate considerably while being brought up to speed. Do not be alarmed at this. When this occurs admit a little more steam quickly to get the rotor above the "critical speed," when the vibration will ordinarily cease. Acquire the habit of shutting down the turbine by tripping the emergency governor, which should automatically operate at 10 to 12 per cent. above normal speed.

Sometimes, just after the machine gets its load it will lag, i.e., be slow or "jerky" with its speed. Frequently, this is due to the pilot valve for the main steam-admission valve sticking, owing to carbon which has collected on the stem. Pour on some kerosene for the time being, but clean the valves as soon as the unit is stopped. In case of any unusual disturbances inside the casing, as the noise due to rubbing of the blades, trip the emergency governor to avoid serious damage or, perhaps, a wreck.

For best economy the clearances between the tips of the blades and the casing and between the sides of the station-

PRESSURE AND VELOCITY CHANGES IN STEAM TURBINES

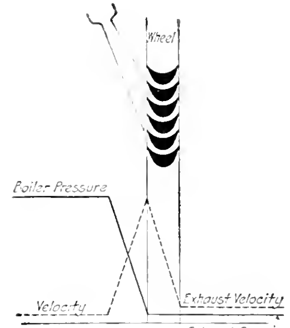


FIG. 5

Fig. 5. Pressure and velocity changes as they occur in single-stage turbines, which type most small turbines represent. Notice that the pressure drops completely in the nozzle and the velocity completely in the moving wheel.

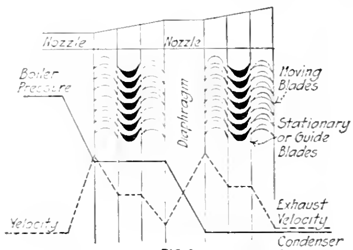


FIG. 6

Fig. 6. Multi-pressure, multi-velocity staging. The pressure in each stage is constant, but is dropped in a nozzle before each stage. Large Curtis vertical machines use the energy in this way. The turbine is an impulse machine.

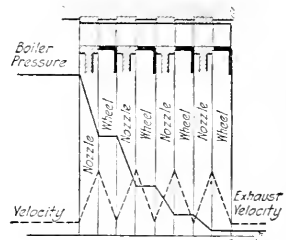


FIG. 7

Fig. 7. Pressure and velocity changes as carried out in the multicellular (impulse) type. This kind of turbine is a multi-pressure, single-velocity machine, of which some of the De Laval, Zoelly, Kerr, Rateau and others are representative types.

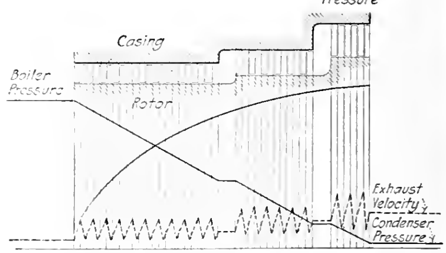


FIG. 8

Fig. 8. Shows how the "pure" reaction, or Parsons, types of turbines use the energy in the steam. The pressure is dropped very gradually through many rows of blades, there being no large increase in velocity anywhere in the machine.

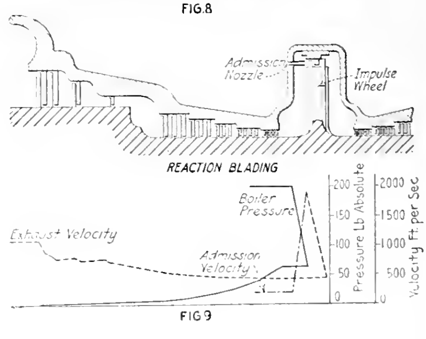


FIG 9

Fig. 9. Pressure and velocity changes as made in the composite design, with velocity staging in the high-pressure element and pressure staging in the low-pressure element. The diagram relates particularly to the Westinghouse double-flow turbine. Many turbines here and abroad are of the composite design.

ary and the moving blades, and between the dummy pistons and their rings, if a single-flow Parsons-type machine, must be small, a comparatively few thousandths of an inch in all cases. Because of the high speeds at which turbines run and because of the small clearances, it is essential that the rotor be in mechanical balance. Adjusting clearances and putting a rotor in balance are jobs requiring skill carefully applied. Time does not permit of taking up these subjects in this lecture, though they are of much interest and importance to the operating engineer.

Steam-Generating Methods, Cleveland Municipal Plant

By A. D. Williams

SYNOPSIS—This large central plant uses economizers. The gates in the hopper outlets of the coal bunker are opened and closed by compressed air, the control being in the hands of the coal-telpher operator. Detray-type boilers are used. Stoker and draft controls are interesting.

In designing the new, or East Fifty-third Street Cleveland municipal lighting plant, F. W. Ballard has used motor-driven auxiliaries throughout, but has provided a steam-driven boiler feeder and a turbo-exciter for emergency service. This plan has simplified the piping systems and eliminated the exhaust steam feed-water heater. Large-sized, high firebox boilers are used, with induced- and forced-draft fans, and the waste gases from the boiler are passed through an economizer for heating the feed water.

The plant is on the shore of Lake Erie at the foot of a steep bluff on the top of which are the tracks of the Lake Shore R.R. and a siding from which two spurs extend over the coal bunker. The height available at this point was not sufficient to permit of placing the bunkers above the boilers without excavating to a considerable depth below the water level of the lake. As the result of this condition, the station practically consists of three parallel structures—the coal-bunker section on the east, the electrical section on the west and the boiler section in the center.

The bottom of the bunker consists of 40 steel-plate hoppers, each provided with a gate opened and closed by a compressed-air cylinder whose operation is controlled by the coal-telpher operator. The telphers run on transverse tracks below the east section of the bunker and are carried by a transfer crane below the west section, an arrangement which permits coal to be drawn from any section of the bunker and delivered to any boiler. Each telpher is provided with a weighing hopper, and the operator on each watch turns in a report of the amount of coal and the time at which coal was delivered to each boiler.

Fig. 1. Aisle below Bunker Showing Hopper Bottom with Air-Operated Gates for Loading Telpher

The present installation comprises five Delray-type Stirling boilers, each fired by two six-retort Taylor stokers. Exceptionally large structural-steel coal hoppers are provided for each stoker, from which the coal flows by gravity to the grates. The central space between the two stokers is closed by dump plates, from which the ashes and clinker are dropped into an ashes hopper. An industrial track is laid in the concrete floor of the boiler-room basement, and upon this are operated steel side-dump ash cars and a storage-battery-operated electric ash car. These cars are used to carry the ashes outside of the building to a point where they can be used in filling in and extending the city property to the harbor line established by the United States engineers.

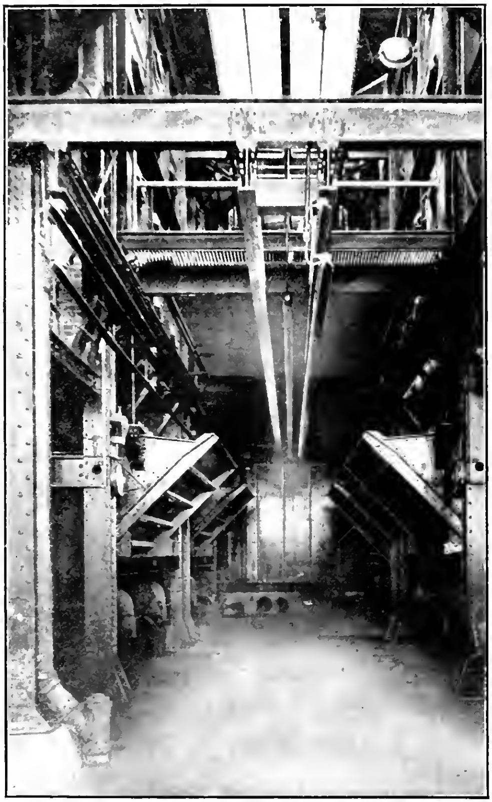


Fig. 2. Firing Aisle. Note Large Stoker Hoppers

The fire area below the boiler is approximately 200 sq.ft., for an average height of about 10 ft. to the bottom of the two mud drums. From this height up the combustion chamber is shaped like a wedge, point up, with a height of nearly 20 ft., the two sloping sides being formed by the tubes of the first pass. This arrangement gives ample space for the flame to form, and the combustible gases are not chilled below the igniting temperature by the comparatively cold tubes of the boiler. In operation the interior of this chamber shows a clear white flame at the lower portion and transparent orange above. As one pound of gas occupying a unit volume in the blast main will occupy five volumes in the combustion chamber and one and one-quarter volumes at the uptake, there are some reasons for providing space for this expansion. The second pass of the gases brings them in contact with the superheater tubes, and at the end of the third pass they flow into an overhead smoke flue. On test the gas temperatures at this point ranged from 510 deg. F. at 106 per cent. rating to 832 deg. F. at 273 per cent. rated load.

In this plant the stokers and the forced-draft fans are operated by separate motors. The speed of the fan motors is governed by controllers operated by changes in boiler pressure, while that of the stoker motors is controlled by changes in blast pressure. The small houses which protect these speed controllers are shown at the left side of the aisle in Fig. 2. Additional control of the draft is supplied by the induced-draft fans, which are operated by motors with manual speed control by means of which the boiler tenders can keep the combustion chamber close to or slightly above atmospheric pressure. This method of operation obviates any tendency of air to seep into the settings through the brickwork or around the cleanout doors and is particularly desirable when it becomes necessary to bar the fires, as there is no tendency to either chill the furnace or burn the firemen. In practice this plan seems to work out well.

From the boilers the waste gases are carried to the economizers and the stack by sheet-steel flues. The stack provided is not designed to supply draft, and for that

PRINCIPAL STEAM GENERATING EQUIPMENT OF EAST 53RD STREET STATION, CLEVELAND MUNICIPAL ELECTRIC LIGHT PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
5	Boilers	Stirling, Delray type	10,134 sq.ft. heating surface	Steam generation	225 to 275 lb. pressure; 125 deg. to 150 deg. F. superheat	Babcock & Wilcox Co.
10	Stokers	Taylor underfeed	6 retort	Under boilers	From standby to 275 per cent. boiler rating	American Engineering Co.
6	Motors	Variable speed	10-hp	Stoker drive	725 to 1125 r.p.m., 220 volts, 37.5 amp., direct current	Diehl Mfg. Co.
6	Speed controllers	Pressure controlled	10-hp	Stoker drive	220-volt	Cutter-Hammer Mfg. Co.
6	Speed controllers Operators			Stoker drive	Controlled by air duct pressure	Mason Regulator Co.
5	Fans	Multivane	36,000 cu.ft. air per min.	Forced draft	7 in. of water pressure	B. L. Sturtevant Co.
5	Fan motors	Variable speed	75-hp	Forced draft	600 to 730 r.p.m., 220 volts, 282 amp., direct current	Allis-Chalmers Mfg. Co.
5	Speed controllers	Pressure controlled	75-hp	Forced draft fans	220-volt	Cutter-Hammer Mfg. Co.
5	Speed controllers Operators			Forced draft fans	Controlled by boiler pressure	Mason Regulator Co.
2	Fans	Steel housed	16x7-ft.	Induced draft	Belted to motors; 70 to 210 r.p.m.; 101,000 to 325,000 cu.ft. per min., 1 in. draft at economizer inlet	Green Fuel Economizer Co.
[illegible]	Fan motor	Induction variable speed	200-hp	Induced draft	695 r.p.m.; 3-phase; stator 2300 volts, 47.5 amp.; rotor 479 volts, 207 amp.	Allis-Chalmers Mfg. Co.
[illegible]	Fan motor	Variable speed	200-hp	Induced draft	540 to 740 r.p.m., 220 volts, 745 amp.	Allis-Chalmers Mfg. Co.
[illegible]	Speed controll	Manual	200-hp	Induced draft		Cutter-Hammer Mfg. Co.
[illegible]	Economizer		2 sections in multiple, 27,000 sq.ft. heating surface	Feed water heater	Waste gases from boilers	Green Fuel Economizer Co.
1	Scraper motor	Induction	3-hp	Economizer soot scrapers	1200 r.p.m., 3-phase, 60-cycle, 220 volts	General Electric Co.
1	Scraper motor	Induction	7.5-hp	Economizer soot scrapers	1200 r.p.m.	
1	Chimney	Concrete lined	13-ft. diameter, 150 ft. high	Removal of waste gases	Induced draft	General Concrete Cons. Co.

reason has been made only of a height sufficient to carry the waste gases up to a point at which they will not become a nuisance to neighboring property. The two induced-draft fans are close to the base of the stack and discharge into it, each being of a capacity sufficient to handle all the load.

The normal operation of this plant provides for the heating of the feed water by the economizers. This installation is divided in two sections, each containing 824 twelve-foot tubes, the total heating surface in both sections being 27,000 sq.ft. Each section of the economizer can be operated independently or may be cut out by dampers. A bypass flue is also provided to lead the waste gases direct to the induced-draft fans.

SPACE AND VOLUMETRIC DATA OF THE STATION

Turbine room and switch gallery		8100 sq.ft.
Sq.ft. per normal kw	0.54	
Sq.ft. per maximum kw.	0.36	
Boiler room		9230 sq.ft.
Sq.ft. per boiler hp. installed	1.82	
Sq.ft. per boiler hp. (6 boilers)	1.52	
Sq.ft. per kw. normal	0.615	
Sq.ft. per kw. maximum	0.410	
Boiler room plus bunker space		15,330 sq ft.
Sq.ft. per boiler hp. installed	3.02	
Sq.ft. per boiler hp. (6 boilers)	2.52	
Sq.ft. per kw. normal	1.024	
Sq.ft. per kw. maximum	0.682	
Total ground area of station		25,360 sq ft.
Sq.ft. per kw. normal	1.68	
Sq.ft. per kw. maximum	1.13	
Volume turbine room and switch gallery		500,000 cu.ft.
Cu.ft. per kw. normal	33.33	
Cu.ft. per kw. maximum	22.22	
Volume boiler room		567,000 cu.ft.
Cu.ft. per boiler hp. installed	11.19	
Cu.ft. per boiler hp. (6 boilers)	9.34	
Cu.ft. per kw. normal	37.80	
Cu.ft. per kw. maximum	25.20	
Volume boiler room plus bunker space		841,000 cu.ft.
Cu.ft. per boiler hp. installed	16.55	
Cu.ft. per boiler hp. (6 boilers)	13.85	
Cu.ft. per kw. normal	56.10	
Cu.ft. per kw. maximum	37.40	
Volume of building		1,420,000 cu.ft.
Cu.ft. per kw. normal	95.00	
Cu.ft. per kw. maximum	63.20	

The present installation comprises:

3 main generating units, normal rating	5000 kw. each
maximum rating	7500 kw. each
Five boilers, each having 10,134 sq.ft. heating surface. Space has been left for a sixth boiler.	
Coal storage capacity in bunker	3400 tons
Coal storage per boiler hp.	1114 lb.
Coal storage per kw normal	454 lb.
Coal storage per kw. maximum	304 lb.

The total length of the economizer is 55 ft. 7 in. and it is so designed that the free area between the tubes is reduced as the gases become cooler.

ECONOMIZER DATA

Number Sections	Number Headers	Tubes per Header	Tubes per Section	Total Number Tubes	Free Area Each Section, sq.ft.	Total Free Area Both Sections, sq.ft.
2	16	6	96	192	56.7	113.4
2	16	8	128	256	49.9	99.8
2	60	10	600	1200	42.9	85.8
2	92	..	824	1648	....	..

Under present conditions only five boilers are installed and there are 4.75 sq.ft. of economizer heating surface per nominal boiler horsepower. When the sixth boiler is in place this will be reduced to 4.44 sq.ft. At present the station is operating considerably below its capacity, and only one section of the economizer is in use at a time. Owing to this condition it is not fair to present the operating results obtained.

[As told in other issues of POWER describing other features of this plant, the station is the largest municipal electric plant in the United States.—EDITOR.]

What Causes the High Efficiency of Locomobiles?

By E. R. PEARCE

To what is the high efficiency of the locomobile mainly due? Some are under the impression that it is due to there being practically no steam pipe between the engine and boiler to cause radiation and condensation. This opinion does not appear to carry much weight when one considers that there are many independent engines working with the steam conditions at the cylinder, both as to temperature and dryness, the same as on the locomobile and yet not having anything like its high efficiency.

In the locomobiles the engines are of the piston-valve type, identical in all respects except for a few minor details. Some of these sets, as built by Wolf and Garrett, have the high- and the low-pressure cylinders placed on the boiler at the firebox end, side by side, and are simply jacketed with live steam at boiler temperature, so that any flow of heat through the high-pressure cylinder walls due to the superheat is not lost, but is taken up by the jacketing steam, eventually passing back into the engine.

That which appears to be the biggest factor in securing high economy is the resuperheating of the steam between the cylinders. There seems to be very little difference in the results obtained whether the cylinders are arranged as mentioned, and steam jacketed, or in tandem, with the high-pressure cylinder jacketed by flue gases. This alone tends to point to the gain being derived in the reheating, thereby preventing condensation in the low-pressure cylinder, which is undoubtedly responsible for the bad performances given by many well-designed engines.

On the smaller sizes there is no reheater, the low-pressure cylinder being jacketed with live steam. Usually, these are very efficient, but do not come up to those having reheating. In the latter type the consumption shows marked reduction as the superheats increase, which, in the case of a Wolf engine of the tandem type rated at 60 hp., is as follows:

I

Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	340.0C
Temperature of steam entering the low-pressure cylinder	171.0C
Superheat entering the high-pressure cylinder	151.9C
Superheat entering the low-pressure cylinder	57.9C
Steam consumption at 43.2 b.hp	10.9 lb.

II

Temperature of saturated steam	190.9C
Temperature of steam entering the high-pressure cylinder	360.0C
Temperature of steam entering the low-pressure cylinder	191.0C
Superheat entering the high-pressure cylinder	172.9C
Superheat entering the low-pressure cylinder	71.4C
Steam consumption at 55 b.hp	10.29 lb.

The difference in the two cases is undoubtedly due more to the increased superheat than to the heavier load, as after the half-load point has been reached the consumption is nearly constant. Like the locomotive, the greater part of the evaporation takes place at the firebox, but averages about 4 lb. per sq.ft. for the total heating surface. This type of boiler has two other strong points in its favor—there is no chance of leaky brickwork, and the end plates and tubes being removable for cleaning purposes, all parts are easily examined and kept in order.

The question now arises as to whether like results could not be obtained on well-designed existing engines by introducing a reheater between the high- and low-pressure cylinders and carefully lagging them, assuming that the gain in efficiency would warrant the expenditure.

Hill-Tripp Centrifugal Pump

The Hill-Tripp Pump Co., of Anderson, Ind., has recently placed on the market a centrifugal pump designed for a number of uses. One- to six-stage pumps are made with capacities ranging from 10 to 20,000 gal. per min., and these pumps are designed to pump against heads of from 10 to 1000 ft. The double-suction single-stage pump is designed for a maximum head of 300 ft. and multistage pumps for heads up to 700 ft. For higher pressures an extra heavy multistage pump is built.

The special feature of these pumps is the impeller, with sides extending a certain distance beyond the vanes, as shown in Fig. 1. The passage formed between the two sides beyond the vanes is flared out, increasing gradually to larger area. In all centrifugal pumps the water leaves the vanes in a tangential direction and at practically the circumferential velocity of the wheel at the extremity of the vanes. This being the case, the relative velocity between the extended sides of the impeller and the water is low and, as a consequence, there is little friction. The shape of the extended sides of the impeller is much the same as the secondary part of a venturi tube, with the added advantage that the tube travels with the water. Owing to the design the velocity head of the water is transformed into pressure before the water leaves the impeller, and as it passes out into the casing the movement of the water is slower than in the suction or discharge pipes. The loss occasioned by stationary vanes is obviated and, consequently, an efficiency as high as 72 per cent. is claimed for these pumps.

As indicated in the drawing at the left of Fig. 1, single-stage pumps have a newly patented balancing device consisting of a central rib in the pump casing, which will deflect the water discharged by the impeller in such a way as to cause increasing or decreasing pressure in the two sides of the casing. If the impeller should move to the left the pressure would increase on the same side and force the impeller in the opposite direction, or *vice versa*. In other words, the pressure against the two sides of the impeller must balance and hold the rotating element in a central position.

For the multistage pump a hydraulic device has been adopted of the general type commonly employed by builders of multistage pumps, with the exception that the present arrangement is double-acting. As shown in Fig. 2, a piston with a renewable ring is secured to the shaft and rotates with the impeller. A pressure chamber is located between this rotating piston and a stationary part, also provided with a renewable ring opposing the ring on the piston. Through a running clearance between the stationary part and a covered sleeve on the shaft, water from the high-pressure end of the pump gradually finds its way into the balancing chamber.

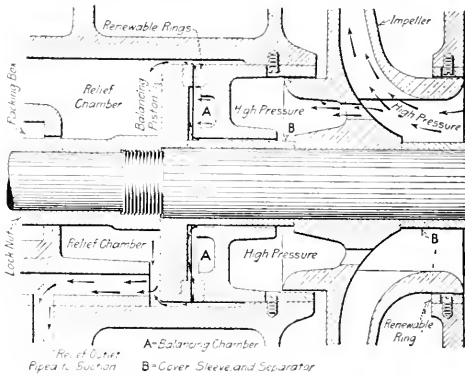


Fig. 2. Details of Balancing Device

Eventually, the pressure in this chamber builds up enough to force the rotating piston away from the stationary element. In this way a circular passage is opened up between the rings, and water flows from the balance chamber to the relief chamber behind the piston. The relief chamber is connected with the suction of the pump, as indicated in the drawing. As the water escapes between the rings the pressure in the balance chamber is reduced until a balance is established. A thin film of water is maintained between the rings, and the rotating parts float continuously at a certain distance from the stationary element. The balancing chamber is made large enough to care for large differences in pressure, which in high-lift pumps may amount to several

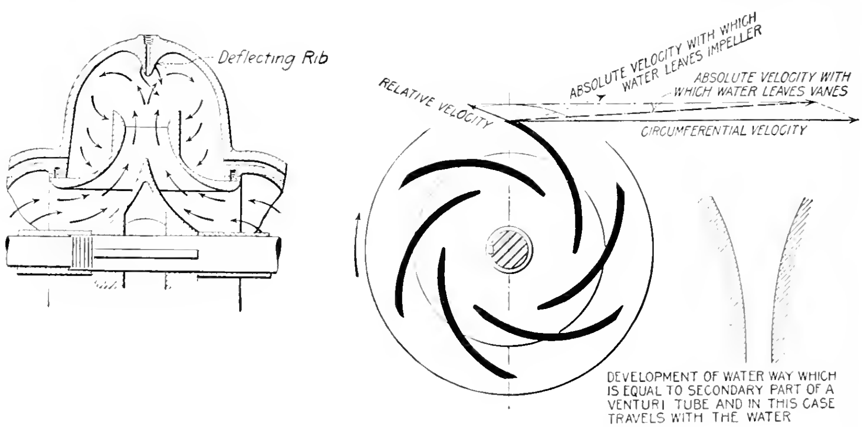
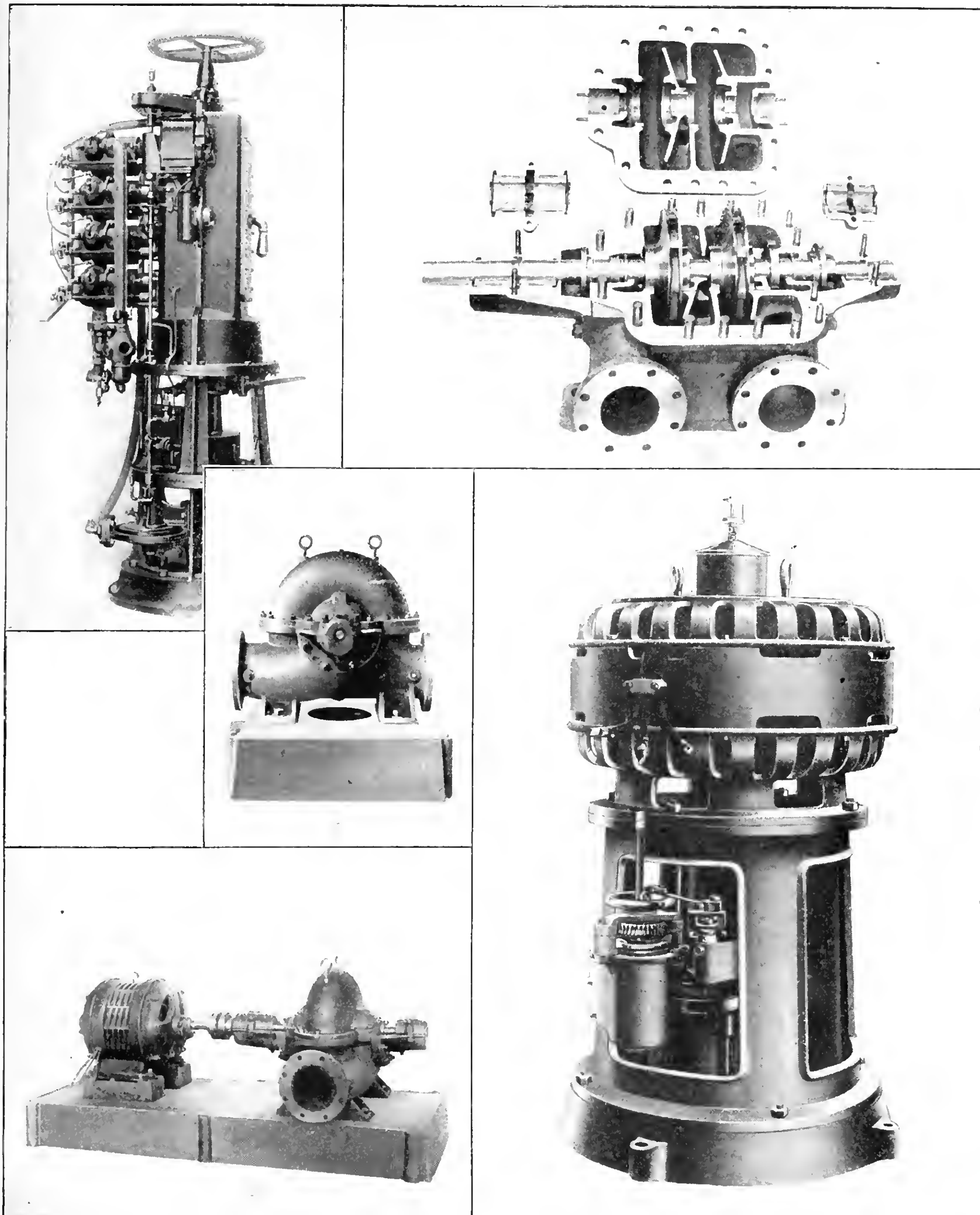


Fig. 1. Showing Special Features of Impeller Design



Figs. 3 to 7. Showing Various Applications of the Pump to Deep-Well Head, High-Lift Centrifugal Pump, and Vertical Discharge Head, Motor Driven

tons. It has been found desirable to make this provision in spite of the fact that each impeller is itself hydraulically balanced independently of the balancing system.

Should the piston have a tendency to move too much toward the relief chamber, it will approach the outlet to the suction of the pump and automatically reduce the amount of water escaping. The pressure in the relief chamber will then build up and force the piston in the opposite direction, relieving the outlet and again establishing a balance.

Figs. 3 to 7 show a variety of applications of the pump. Fig. 3 is a deep-well pump head equipped with a four-cylinder high-speed oil engine, fitted with an automatic cutoff for control in case the pump loses its suction or the load is dropped for any reason. Fig. 4 shows a standard multistage high-lift centrifugal pump with the upper half of the casing removed. The construction of the impeller and the balancing and relief chambers is clearly shown in this view. Fig. 5 is a side view of the double-suction impeller split-case centrifugal pump, and Fig. 6 shows the same pump directly driven by an electric motor. Fig. 7 shows a vertical discharge head equipped with a motor for driving and a hard oil pressure pump.

The Government as a Buyer of Power

By A. P. Connor

Some of the conditions of the contract under which the United States Government buys electric current within the District of Columbia are given herewith.

Schedule No. 1 provides that for a monthly current consumption up to 3200 kw.-hr. the rate shall be 6c. per kw.-hr.; up to 4545 kw.-hr., 5½c.; 7500 kw.-hr., 5c.; 12,500 kw.-hr., 4½c.; all current in excess of 12,500 kw.-hr. per month, 3c. But separate buildings (not connected by a covered passageway) must be metered separately, so that the total current used in a group of detached buildings occupied by one department might entitle that department to the minimum rate, yet by the separate metering process the maximum rate would be collected. Schedule 4 is a work of art, as will be seen by careful reading.

SCHEDULE NO. 4—FOR BUILDINGS WHERE PRIVATE GENERATING PLANTS ARE NOW INSTALLED

For electricity used during months from April to September, inclusive, $0.025 per kw.-hr.

This service to be entirely optional with the Government, and will become operative only upon the written request or authority of the particular department or governmental establishment desiring it, and it will be furnished only during the period from Apr. 1 to Sept. 30, inclusive, or for such portion thereof as the service may be required; in cases where service is furnished under Schedule No. 4, during the period from July 1 to Sept. 30, inclusive, or any part thereof, and where any service is required from the contracting company at any time during the period from Oct. 1 to Mar. 31, inclusive, the charges for the service furnished during the period from Oct. 1 to Mar. 31 shall be in accordance with Schedule No. 1, 2, 3 or 5, as may be applicable and selected by the Government, and the charges for the service furnished during the period from July 1 to Sept. 30 shall be adjusted to conform to the rates of charge in force during the period from Oct. 1 to Mar. 31, or any portion thereof, and the contracting company shall be paid the full amount of the difference. Schedule No. 4 is not to be available during the period from Apr. 1 to June 30, inclusive, for buildings where any service has been required during the period from Oct. 1 to Mar. 31, inclusive.

By the terms of this schedule, suppose during the six summer months current to the moderate total of $2500 had been used at the 2½c. rate, and that during the winter for a short period (a single day) it became necessary to obtain current from the electric service company, the only such contractor in the field, the answer according to the schedule would be: "Yes, we will furnish you the current (service lines already in) for 6c. per kw.-hr. provided you pay a penalty of $3500 for having taken current from us during the summer (which we were glad to sell at that time of the year) at 2½c. per kw.-hr."

It seems beyond the belief of a reasonable person that such rates have been approved by the Government. This is probably the most flagrant case of a contract unfavorable to the Government that can be found, and since it has existed for a long period there is reason to believe that it may be continued for many years.

Is it advisable for the engineer of a department to accept and insist on the 2½c. rate (after the apparently sincere advice of an official close up to the Secretary not to attempt to save money for the Government at the risk of his personal welfare and possibly his position), or should he permit the handing over of more than double the money for the service during the summer in order to avoid the personal risk? If he succeeds in the saving, what is there to it for him except "art for art's sake?" If he fails to get through the winter without a holdup, what then? Perhaps a little light obtained in a court proceeding in a test case in which the subject matter was the rate and the apparently piratical charge for back service, would clear up the situation. It has been established beyond a doubt that 2c. a kilowatt-hour is a familiar rate of the same utility for current in buildings in the immediate vicinity of Federal buildings. The rates which the same utility charges other parties is a matter of record with the Public Utility Commission of the District of Columbia (and easily obtainable), and under the control of the Government.

The time of the day in which the greater part of the current is used by the Federal departments is certainly favorable to a central station carrying a substantial commercial and street-railway load, and in this case the utility has one of its power stations located most centrally with respect to the governmental buildings and departments.

The State Department recently rented a certain hotel building and by means of a few feet of conduit and rewiring, it was possible to get power (electrically) from the plant of the State, War and Navy Building at a cost of about $30 a month, but the Comptroller of the Treasury decided that there was no authority of law for extending the government service or system to a "private building," although the hotel was used by the department for office purposes. The current bought from the Potomac Electric Power Co. will cost about $100 a month.

It is gratifying to learn that the project to erect a central power station by the Government which has so long met with steady opposition from certain quarters is progressing and the initial bids will soon be opened. The hydro-electric project to utilize the enormous water-power possibilities of the Potomac River in the District of Columbia does not progress. The curious might ask, "Why are these things thus?"

Correctly Designed Steam Lines skillfully erected are no more likely to fail and interrupt the service than other features, not duplicated. It is a matter of common experience that the hydraulic piping in a plant causes less trouble than the low-pressure house-service piping, because of the difference in installation. The same is applicable to steam piping.

A Sulzer Diesel Engine, built for Messrs. Harland & Wolff, for generating electricity in that firm's shop at Belfast, is said to be the largest Diesel yet constructed to a definite order. It is of the two-stroke cycle, single-acting type with six cylinders, and was designed to develop 3750 b.hp. at 142 r.p.m., though on trials 4500 b.hp., or about 750 b.hp. per cylinder, was maintained for a long period. The cylinder dimensions are approximately 30 in. bore by 40 in. stroke.—"Gas and Oil Power."

Chimneys for Oil- and Coal-Burning Plants

By F. H. Rosencrants

SYNOPSIS—Available data on chimney design relate almost solely to coal-burning plants, while little is applicable to oil burning. For given conditions a much smaller chimney is required for oil.

That a difference exists in the requirements in stack dimensions for a plant burning coal and for one burning oil is generally understood. Most available data on draft requirements and stack dimensions are applicable to coal-burning plants, so the designer of an oil-burning plant must rely upon his experience and judgment and on the meager amount of serviceable information in designing this important part of the plant. The most comprehensive treatment of stacks for oil-burning plants that the writer knows of is that written by C. R. Weymouth, presented before the American Society of Mechanical Engineers and published in bulletin form by Chas. C. Moore & Co., of San Francisco, Calif.

In a coal-burning plant it is important that the draft shall be sufficient to burn the maximum desirable amount of coal per unit of time per unit area of grate. Draft in excess of this merely provides additional overload capacity which may or may not be desirable. The objectionable feature to excessive draft in a coal-burning plant is the interest and depreciation charges for the increased cost of the stack to produce the excess of draft. However, engineers are more afraid of a deficiency than of an excess, and formulas deduced are usually liberal.

In a coal-burning plant the rate at which the boiler is steaming will demand a certain rate of combustion which requires a proportionate increase in draft. Therefore, the dampers will demand the required amount of attention from the attendant.

In an oil-burning plant the rate of steaming demands the combustion of oil at a certain rate, but this is dependent upon the position of the oil-control valve and not upon the existing draft. The boiler might be operated from no load to full load with the same damper setting, provided that setting would furnish the required amount of air for the maximum load. So at all loads below the maximum there would be an excess of air, and the smaller the load the greater the excess and consequent decrease in boiler efficiency. This condition would be accompanied by a smokeless stack and a careless or ignorant fireman might be led to think that he was running the plant economically. The trained fireman of an oil plant knows that a faint haze at the top of the stack is desirable, as that tells him that if he admits less air the stack will smoke and if more the stack will be clear and an unknown amount of excess air entering the furnace.

If the possible draft of a stack for oil burning is in excess of that required to produce the maximum desirable load, it has the double disadvantage of possible large excesses of air and of possible overloads on the boiler which might be destructive to the settings. In addition to this, there is the same disadvantage that exists with coal-burning plants, namely, the interest and depreciation charges on the cost of the excess stack capacity.

Comparative Cross-Sectional Areas of Stacks

Assuming the same velocity of the gases up the chimney for oil as for coal stacks, the former need be much smaller in cross-section than the latter for the same capacity.

Assuming an excess of air of 50 per cent., the weight of flue gases per pound of oil will be about 22 lb. Assuming a heating value of 19,000 B.t.u. per pound and a boiler efficiency of 75 per cent., the weight of flue gases per 1000 effective B.t.u. will be

$$\frac{22}{19{,}000 \times 0.75} \times 1000 = 1.544 \textit{ lb.}$$

Assuming values for coal which are attainable with the same amount of skill as those quoted for oil, we have, allowing 100 per cent. excess air, 25 lb. of flue gases per pound of coal; 12,500 B.t.u. heating value per pound; and a boiler efficiency of 70 per cent. Using these figures, the weight of gases per 1000 effective B.t.u. becomes

$$\frac{25}{12{,}500 \times 0.70} \times 1000 = 2.857 \textit{ lb.}$$

It follows from the preceding calculations that, assuming the same rate of steaming in both cases, the amount of gas which will pass up the oil-burning stack will be only $1.544 \div 2.857 = 0.541$ as much as that which passes up the coal-burning stack, therefore an oil-burning stack for a given capacity need be only about 0.54 as large in cross-section as a coal-burning stack.

Comparative Heights

It is impossible to give any hard and fast rule for the height of a coal- or oil-burning stack, as so much depends upon variable factors, such as altitude, length of breeching, character of fuel, rate of combustion, etc. However, it can be conclusively shown that in any and all cases the height of an oil-burning stack will be much less for the same set of conditions than that of one burning coal.

The draft in any case must overcome the resistance of (1) the furnace, (2) the passes of the boiler, (3) the damper box, (4) the breeching including its turns, and (5) the stack itself.

Comparing the oil-burning with the coal-burning plant with reference to the first, it is evident that the furnace resistance of the former is much less than the latter. Due to the injector action of the oil burner, the furnace resistance in the case of oil burning often is negative; i.e., the injector action of the burner produces a slight pressure. The furnace resistance when burning coal varies with the character of the fuel and the variation in thickness of fuel bed and with the rate of combustion. With average bituminous coal and a rate of combustion of 20 lb. of coal per square foot of grate per hour, the furnace resistance amounts to about one-quarter inch of water.

With reference to the second element of draft, the oil-burning plant again has the advantage. As shown, the weight of gases for oil as compared with those for coal for the same rate of steaming is a little over one-half as much; so the velocity of the gases through the boiler is a little over one-half as great. Since the resistance to the flow of fluids varies with the square of the velocity, the boiler resistance for oil burning will be not over one-third of that for coal.

The resistance of the breeching and stack will, of course, depend upon the velocity of the gases through them, but assuming the velocity to be the same in the two cases, the resistances would also be equal, or nearly so.

It is evident from the above that the draft requirement for burning coal is in excess of that required for oil and since the draft of a stack varies with the square-root of its height, the height of a stack for burning coal is much greater than that for burning oil. It will nearly always be twice as high or more for the same rate of steaming.

It might be suggested that an oil-burning boiler could be operated at a higher rate of evaporation per square foot of heating surface than is usual for coal, since the weight of gases is so much less for the same rate. It has been found in many tests that the efficiency is improved when so operated, but the temperature produced in the furnace is destructive to the setting and this disadvantage more than offsets the slight gain in efficiency.

It would seem that, inasmuch as the factors affecting draft resistance in oil burning are so much less variable than with coal, the problem of stack design could be made exact, which is desirable.

Graphic Representations of Power-Plant Losses

By E. D. Dreyfus

SYNOPSIS—By means of a set of charts the operator is apprised directly of the approximate loss incurred, in dollars and cents, through failure to maintain the prescribed conditions.

The large central power plant usually employs a small army of operatives. Those who supervise are generally conversant with the technical requirements necessary for the highest efficiencies, but the force as a whole does not appreciate the significance of the different engineering factors involved; although from a strictly mechanical and operating viewpoint, the men may be capable and trustworthy. Taking cognizance of this, the West Penn Traction Co., of Pittsburgh, set about to devise a remedy by displaying graphically the necessity for observing conditions that have been found to produce the most efficient results. The accompanying charts show the attempts made to fasten the attention of the power-plant employee upon the enormous losses that accumulate during the year when the best working conditions are not maintained.

The object in Fig. 1 is to impress upon the firemen the importance of a high CO_2 percentage. First, it is assumed that an instrument has been installed which will give a direct reading of the CO_2 in the flue gas. Then the "burette" of the CO_2 apparatus is reproduced on the chart, with a simple scale. A standard rule is drawn opposite, with a dollar and cents scale substituted for the customary inch and fractions. The normal, or standard, percentage has been taken at 15 per cent., although a slightly lower rate may prove best in practice. Since this represents the most economical working condition, it is made to correspond to the line of zero waste, or avoidable losses. The rise of the liquid in the "burette" (imaginary, of course, while considering the chart) will be read on the "measuring stick" as indicating greater and greater unnecessary losses.

Owing to the losses in dollars and cents increasing (inversely) more rapidly than the changes in CO_2 percentage, the measurements cannot be taken on the horizontal line since plain scales are used in both cases. Hence, slanting lines are drawn to connect corresponding values.

The charts are constructed upon a simple basis. A fair estimate of the coal to be consumed during the coming year under favorable operating conditions is the foundation upon which rests all the percentages for the different operating factors. Each case is treated independently to avoid complication, although to have dealt with these factors in a cumulative manner would be the technically correct way.

Each plant must, of course, be individually considered when arriving at the percentages in any case, and the figures in the charts are merely indicative of the method.

In view of the quality of the coal and the flue temperatures, the following CO_2 percentages were determined upon:

CO_2 Percentages	Percentage Loss in Fuel	CO_2 Percentages	Percentage Loss in Fuel
15	0.000	9	7.580
14	0.808	8	9.660
13	1.750	7	13.020
12	2.840	6	16.320
11	4.130	5	21.650
10	5.690		

Coming to Fig. 2, giving the losses for operating prime movers at less than normal rated capacity (usually the economical point), it is presupposed that there are a number of units installed which may be cut in and out to conform to the load, so as to maintain a high load factor on the individual machines. Unless a separate chart is provided for each unit, a single one must necessarily be of a compromise character in view of the different sizes and types. Such a compromise curve must be employed with discretion.

Fig. 3, for feed-water temperatures, is similar to Fig. 1, but the losses have been represented by heavy black columns intended to display proportionate waste of coal, each block having its money value indicated. This variation was introduced to ascertain if the one arrangement would possess more force and effect than the other.

In condensing-turbine stations the importance of high vacuums is now fully appreciated. In this case the compromise chart of Fig. 4 was arranged. Other charts may be made if further refinements are carried out in the station.

The power-plant operator has not the same direct appeal to the personal interests of his men as is possible in

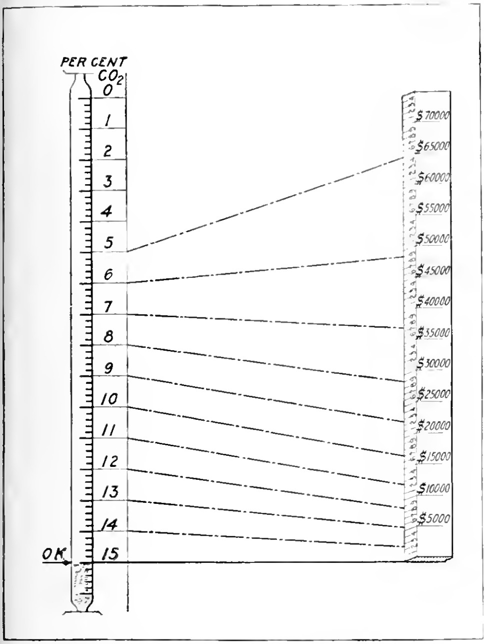


Fig. 1. Chart for CO_2, Showing Money Lost in Wasted Coal through Careless Firing

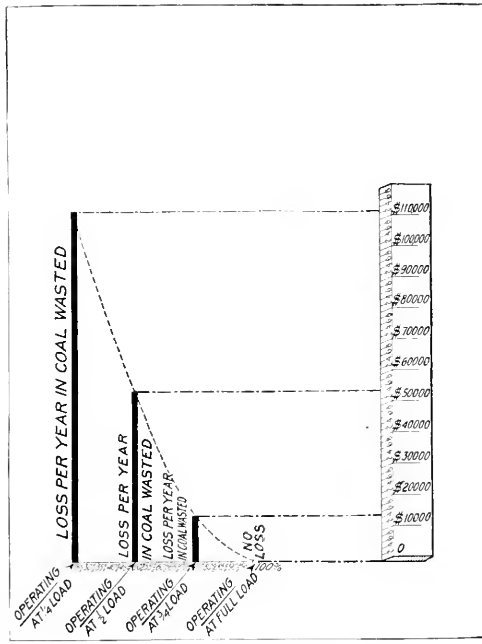


Fig. 2. Chart Showing Money Loss Due to Operating Turbines at Partial Load

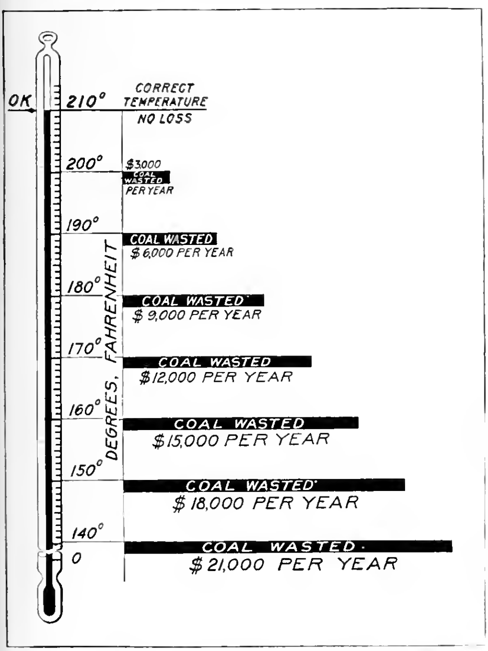


Fig. 3. Money Loss Due to Low Feed-Water Temperatures

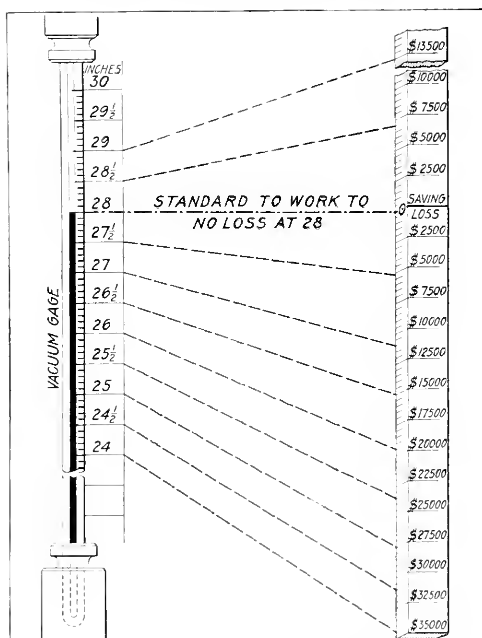


Fig. 4. Vacuum Chart, Showing Money Loss per Year for Variations below 28 In.

some other lines, but the security of the employee's position and, accordingly, his source of livelihood are inseparably linked with the best interest of the owner and his inherent value is gaged in proportion to what he accomplishes compared with the best practicable results obtainable within his sphere of duties.

Interior Wiring for Lighting and Power Service—II

By A. L. Cook

SYNOPSIS—Branch circuits and feeders, insulation, wire sizes, fuses, panel-boards, switches, etc. The first article of the series (May 4 issue) covered voltages and systems employed, the "National Electric Code," the types, number and spacing of lamps, and the determination of the lighting load.

When the size and location of the units have been settled the branch circuits can be arranged. The "National Electric Code" specifies that a branch circuit which is dependent upon a cutout shall not carry more than 660 watts or have more than 16 sockets and receptacles, except by special permission in cases where No. 14 wire can be carried directly into keyless sockets. Under these conditions, 1320 watts and 32 sockets may be used. The arrangement of these branch circuits should be such that the lamps on one branch are grouped as closely as possible. The lamps near the windows should be controlled separately. It is also best to so plan the branch circuits that the wires will not have to cross heavy beams or girders. Details regarding various arrangements of branch circuits will be taken up later.

Incandescent lamps are so sensitive to changes of voltage that it is necessary to maintain a steady and as nearly as possible constant voltage on them, irrespective of the load on the system. The tungsten lamp, however, is not as sensitive as a carbon lamp: for a difference of 1 per cent. in voltage the 12-volt tungsten lamp changes 3.6 per cent. in candlepower, while for a carbon lamp the change is

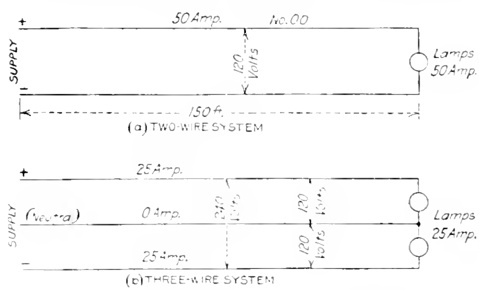


FIG. 3. TWO- AND THREE-WIRE SYSTEMS

5.6 per cent. Because of this effect, lighting circuits should not be supplied from motor circuits, but should be run independently. The voltage drop in a lighting system carrying full load should not exceed the following: Branches, 1.5 per cent.; mains, 0.7; feeders, 1.3; total, 3.5 per cent. When there are no mains, the drop allowed for the mains is included in the feeder drop.

Lamps used for indoor lighting should always be operated in multiple, as a series system with arc or incandescent lamps is not desirable, because of the high voltage necessary and lack of flexibility. Even the operation of 120- or 240-volt lamps in series on a 550-volt system is not good practice except in special cases, such as railway power houses or car barns. Because of the limitations of the incandescent lamp the lighting system must employ about 120 or 240 volts, the former being preferable.

The systems of distribution include two-wire and three-wire circuits, either direct or alternating current, and

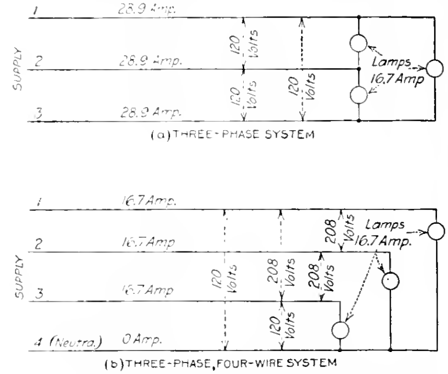


FIG. 4. CURRENT AND VOLTAGE RELATIONS IN THREE-PHASE SYSTEM

three-phase or two-phase. The branch circuits are generally two-wire and will be so considered in the present discussion. The feeders and mains, however, may be arranged on any of the systems mentioned. The two-wire is the simplest, but the voltage is limited to that of the lamps, which cannot exceed 240. When it is remembered that by doubling the voltage, only one-fourth as much copper is required for a given percentage drop, the advantage of using as high a voltage as possible is apparent. On the other hand, the use of 240 volts on lamp circuits increases the cost of maintenance, and the efficiency of the lamps is lower, so that 120 volts is more satisfactory. By means of the three-wire system, with 120 volts between each outside wire and the neutral and 240 between the outside wires, 120-volt lamps may be used; but the power will be transmitted at 240 volts and the copper required will be three-eighths that required for a two-wire 120-volt system. The amount of copper would, of course, be greater than if a 240-volt two-wire system were used, as this would take one-quarter of that necessary for a 120-volt two-wire system. The advantages in the use of 120-volt lamps will, however, generally justify the extra cost of the three-wire system. Fig. 3 represents a two-wire and a three-wire feeder system carrying a load of 50 amp. at 120 volts. One-half of the lamps would be connected across each side of the three-wire circuit.

The three-phase system is sometimes used for lighting, three wires being used, with the same voltage between any two; see Fig. 4. The lamps are divided equally between the three phases. Sometimes a fourth wire, called a neutral, is provided, as shown at *b*. In the arrangement shown at *a*, the copper required is three-fourths that for the two-wire system shown in Fig. 3-*a*, and in the four-wire, three-phase system the copper is one-third that necessary for the two-wire.

The two-phase system is illustrated in Fig. 5. The lamps are distributed equally across the two phases, and it will be seen that the arrangement is the same as two single-phase circuits. There is no electrical connection between the two phases, and consequently no voltage between them. The copper required is the same as for the two-wire system in Fig. 3-*a*. Frequently, two of the wires are combined, as shown at *b*. The copper required for this arrangement is 0.73 times that for the two-wire system. Further details of these systems will be taken up when the method of calculating the circuits is discussed.

Conduits

In the majority of installations rigid, unlined iron conduit is desirable, although the first cost is greater than where the wires are run exposed. The greater freedom from damage to the circuits and the improvement in the appearance of the wiring will generally justify its use. In factory wiring, it is sometimes better to run the feeders exposed, using iron conduits for the mains and branches, particularly in an extensive plant where the feeders can be so located that they are not likely to suffer damage. The conduits must be large enough to allow the wires to be pulled in after the conduits are in place without damaging the insulation. The size depends, therefore, upon the number of bends. The "Code" requires that the maximum number of bends shall not exceed the equivalent of four right-angle bends, and if more are necessary a pull-box must be inserted in the run so that the wire may be pulled in sections. It is desirable to make the radius of the bends as great as is consistent with other limitations. The stock bends, which can be purchased from the conduit manufacturers, can be used, except in special cases, where a longer-radius bend is desirable. The ordinary iron conduit consists of soft-steel pipe made

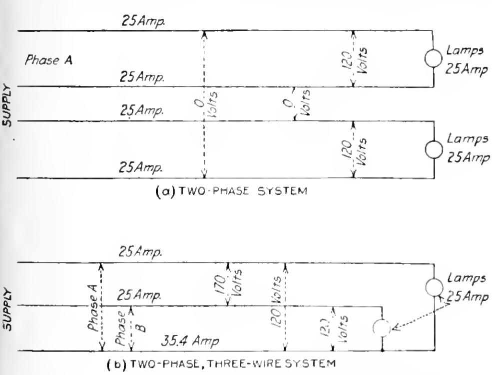


FIG. 5. CURRENT AND VOLTAGE RELATIONS IN TWO-PHASE SYSTEM

in standard-weight iron-pipe sizes and threaded the same. It has a heavy, smooth coating of enamel on the inside to facilitate pulling in the wire and is either enameled or galvanized on the outside. The galvanized conduit is more desirable where it is to be painted after installation, and it can also be more easily grounded as required by the "Code."

In Table 6 are given conduit sizes for various sizes of wires, covering most of the conditions met in practice and suitable for fairly long runs. For longer runs, if the number of bends is decreased, the same sizes may be used; for shorter runs, the size may in some cases be reduced. An approximate rule is to choose such a size that the wires will just be contained inside a circle three-quarters the outside diameter of the conduit. For alternating-current work all the wires of a circuit must be contained in the same conduit. This is required by the "Code," because if run in separate iron conduits there would be excessive

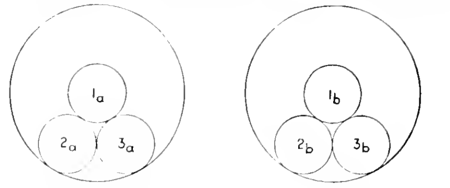


FIG. 6. ILLUSTRATING WIRES IN CONDUIT

heating of the conduits and a greatly increased drop due to the alternating magnetic field produced by the current flowing in the wire. This effect will be greater the larger the current, but even for the smallest wires the rule should be followed. If the conduits are of brass, fiber or tile, the wires can be safely separated in different ones, but even then the drop is so great that it is generally better to combine the circuit in one conduit. If the current is so great as to require more than one wire for each lead of the circuit, and it is not feasible to put them all in one conduit, the leads should be divided into two or more groups, each containing all the poles of the circuit. The proper arrangement for a three-phase circuit is shown in Fig. 6, where the leads of the three phases are 1, 2 and 3 respectively, 1-*a* and 1-*b* being of the same polarity. This rule applies for all types of alternating-current systems except the two-phase four-wire, which is practically the same as two single-phase circuits, and phases *A* and *B* may be run in separate conduits. For direct-current circuits it is satisfactory to employ separate conduits for each wire, if of large size, unless there is probability of a change being made to alternating current.

TABLE 6—SIZES OF UNLINED IRON CONDUIT FOR 600 VOLT N. E. C. STANDARD RUBBER WIRES

Size of Wire	Number of Wires in One Conduit			
	One	Two	Three	Four
14*	½ in.	½ in.	¾ in.	¾ in.
12*	½ in.	¾ in.	¾ in.	¾ in.
10*	½ in.	¾ in.	1 in.	1 in.
8	½ in.	1 in.	1 in.	1 in.
6	¾ in.	1 in.	1¼ in.	1¼ in.
5	¾ in.	1¼ in.	1¼ in.	1¼ in.
4	¾ in.	1¼ in.	1¼ in.	1½ in.
3	¾ in.	1¼ in.	1¼ in.	1½ in.
2	¾ in.	1½ in.	1½ in.	2 in.
1	¾ in.	1½ in.	2 in.	2 in.
0	1 in.	2 in.	2 in.	2 in.
00	1 in.	2 in.	2 in.	2½ in.
000	1¼ in.	2 in.	2½ in.	2½ in.
0000	1¼ in.	2 in.	2½ in.	2½ in.
300,000	1½ in.	2½ in.	3 in.	3 in.
400,000	1½ in.	3 in.	3½ in.	3½ in.
500,000	2 in.	3 in.	3½ in.	3½ in.
600,000	2 in.	3½ in.	4 in.	......
700,000	2 in.	3½ in.	4 in.	......
800,000	2 in.	3½ in.	4 in.	......
900,000	2½ in.	4 in.	4½ in.	......
1,000,000	2½ in.	4 in.	4½ in.	......
1,250,000	2½ in.	......	......	......
1,500,000	3 in.	......	......	......
1,750,000	3 in.	......	......	......
2,000,000	3 in.	......	......	......
14 duplex*	......	½ in.	......	......
12 duplex*	......	½ in.	......	......
10 duplex*	......	¾ in.	......	......

Based on runs not over 100 ft. long and not over four standard bends.

*These sizes are solid; all other sizes are stranded.

Exposed wiring may be run on porcelain cleats, or insulators, the spacing being as follows:

Voltage	Distance from Surface	Distance between Wires
0—300	½ in.	2½ in.
301—550	1 in.	4 in.

For wires not less than No. 8 B. & S. gage in locations where they will not be disturbed, the spacing may be made 6 in. and the wires run from beam to beam, without breaking around. By this means, feeders and mains may be run in a direct line the entire length of a building and supported by the beams or roof trusses. This results in minimum cost and makes a very satisfactory arrangement.

Insulation

Wire for interior work may have two kinds of insulation—rubber or weatherproof—depending upon the method of running the wires. Rubber wire must be used if installed in conduit, but for exposed or so-called cleat wiring, a cheaper insulation is allowed. The rubber insulation used in most installations is called "Code" wire and is manufactured in accordance with very rigid rules contained in the "National Electric Code." Every coil must bear the stamp of the inspection department of the Board of Fire Underwriters, so there is no difficulty in identifying such wire. Sometimes, for important installations, a quality of rubber insulation which is better than "Code" wire is used, and its greater cost is often justified by the resulting reduction in breakdowns on the system. Public buildings, railway stations, office buildings, and sometimes industrial plants can afford to use this better quality for greater insurance against interruptions to the service. No insulation poorer than "Code" wire should ever be used, even if the work is not inspected by insurance representatives.

The insulation used for exposed work consists of two braided-cotton coverings over the copper conductor, the inside covering being impregnated with a weatherproof compound, and the outside one filled with a fireproof compound. This is called "slow-burning weatherproof" wire. Sometimes another type, called "slow-burning," is used, this being similar to the other except that the entire insulation is fireproof. This is satisfactory for dry places where the wires are run exposed on insulators.

In Table 7 are given the safe carrying capacities for various sizes of wire used for interior work as specified in the "National Electric Code." Column A gives values for rubber and column B for "slow-burning weatherproof" and for "slow-burning." It will be noticed that for rubber wire the current allowed is less than for the other insulation, because it is necessary to keep the rubber-covered wires at a lower temperature to prevent damage to the insulation. The currents specified for rubber insulation will cause the wire to run at about 29 deg. F. above the surrounding air.

The "Code" makes no distinction in carrying capacity between alternating and direct current. For alternating currents, especially at 60 cycles, there is a greater drop, particularly for large wires. Even with 500,000-circ.mil cables, the resistance is 2½ per cent. greater and for 1,000,000 circ.mil it is about 11 per cent. greater. This would result in the wires running somewhat hotter when carrying alternating current.

Fuses and Circuit-Breakers

All wiring must be protected by fuses or circuit-breakers in such a manner that the circuit will be opened if the rated current is exceeded. The size of the fuse must not exceed the carrying capacity of wire as given in Table 7. For example, a No. 1 wire, if rubber covered, would be protected by a 100-amp. fuse, and if "slow-burning weatherproof," would have a 150-amp. fuse. When circuit-breakers are employed without fuses, they must not be set more than 30 per cent. above the rating of the wire as given in the table. The excess current which the fuses will carry continuously is about 10 per cent. for inclosed and 25 per cent. for link fuses, which allows small overloads without interrupting the service. The rating in Table 7 is based only on the safe current-carrying capacity of the wires, and should not be exceeded; but it takes no account of the drop in the wires. In many cases, the length of the run is so great that the drop with the rated current would be excessive, in which event a larger wire must be used.

TABLE 7—CURRENT-CARRYING CAPACITY OF WIRES FOR 600-VOLT INSULATION, N. E. C. STANDARD FOR INTERIOR WIRING

Size, Circ. Mils	Size, B. & S. Gage	Rubber Insulation, Amperes A	Other Insulations, Amperes B
1,624	18*	3	5
2,583	16*	6	10
4,107	14	15	20
6,530	12	20	25
10,380	10	25	30
16,510	8	35	50
26,250	6	50	70
33,100	5	55	80
41,740	4	70	90
52,630	3	80	100
66,370	2	90	125
83,690	1	100	150
105,500	0	125	200
133,100	00	150	225
167,800	000	175	275
211,600	0000	225	325
300,000		275	400
400,000		325	500
500,000		400	600
600,000		450	680
700,000		500	760
800,000		550	840
900,000		600	920
1,000,000		650	1000
1,100,000		690	1080
1,200,000		730	1150
1,300,000		770	1220
1,400,000		810	1290
1,500,000		850	1360
1,600,000		890	1430
1,700,000		930	1490
1,800,000		970	1550
1,900,000		1010	1610
2,000,000		1050	1670

Note—Voltage drop is not considered in the above table.

*Wires smaller than No. 14 B. & S. gage should not be used except for fixture wiring and pendant cords.

In lighting installations of any considerable size, there will be a large number of branch circuits, each provided with the proper fuses. For convenience these are grouped, as far as possible, in a panel-board, containing the necessary branch fuses and in some cases the control switches. For industrial plants, slate panel-boards contained in steel cabinets with steel doors are the most satisfactory. For office buildings, etc., slate panel-boards with steel cabinets set flush with the surface of the wall are generally required. The doors are preferably made of wood to match the trim of the building, although steel doors are sometimes used. While economy demands as few panel-boards as possible, a single board should not contain more than 30 branch circuits. If more must be supplied from the same point, it is better to use a double panel-board with two sets of busbars and two doors. Each branch should contain fuses for protecting the circuit and in many cases a branch switch is also provided. These switches should be placed next the busbars, so that when open, the branch circuit fuses may be replaced without danger of short-circuit or shock. Branch circuit switches are not really necessary, except when used to control the branch circuits. In many industrial establishments, it is best to keep the panel-boards locked and provide switches outside for controlling the lights. This arrangement should also be used in office buildings. For public buildings, such as railway stations, most of the lights are controlled directly from the panel-board switches and in many factories this is done to save the cost of additional switches. The feeders supplying the branch circuits must be run to some central point of supply such as panels on the switchboard. If central-station service is used, it is best to install a regular switchboard except when the number of feeders is small, in which case a panel-board can be used. In every case, a suitable switch disconnecting every wire of a feeder should be provided for each circuit. The largest size of fuse allowed by the "Code" is 600 amp. for voltages up to 250 and 400 amp. for 600-volt circuits. Circuits requiring more current than this have to be protected by circuit-breakers. Lighting circuits are not subject to large overloads, so that the fuses should not blow unless there is a short-circuit. If circuit-breakers are used in place of fuses and are arranged to automatically trip out when closed on an overload, the switch may be omitted. Fuses or circuit-breakers should be large enough to give the full carrying capacity of the wires, in accordance with Table 7, even if the actual load on the feeders is considerably less.

Wiring Accessories

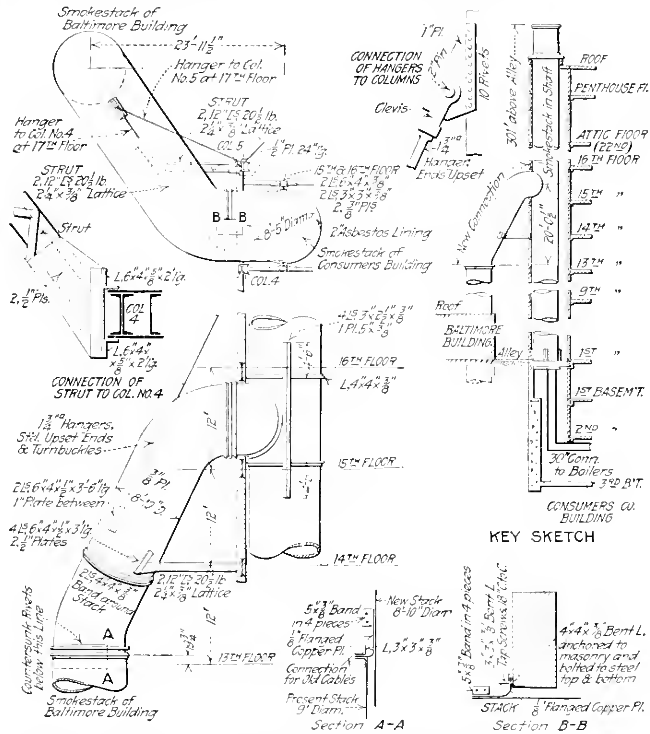
A detailed discussion of the wiring fittings, such as sockets, switches, outlet boxes, and the like, does not properly belong in this article, but a few suggestions may be of value. For exposed conduit work, complete lines of devices such as condulets have been developed to meet almost any requirement, and their use assists greatly in making neat work. For ceiling outlets, where there is no danger of the lamps' being hit, a "T" fitting may be conveniently used, the drop to the lamp consisting of a piece of half-inch conduit. Enameled reflectors are provided complete with sockets, which can be attached directly to this pipe. Glass reflectors require the use of an ordinary keyless socket with a suitable shade holder. Tungsten lamps will operate satisfactorily in this type of fixture, unless there is excessive vibration, in which case it may be necessary to use flexible cord for the drop. For concealed rigid conduit work, the outlets are provided with pressed-steel boxes, which should be galvanized rather than japanned, to assist in grounding the conduit system. Control switches outside the panel-boards may be either of the rotary or push-button variety; the latter is better for offices and the rotary switch, which is somewhat cheaper, is satisfactory for industrial establishments. Nothing smaller than a 10-amp. switch should be used, for the sake of mechanical strength.

Conductivity and Resistance are relative terms. It is customary to divide all material into three groups depending on their relative conductivity: First, metals and their alloys are good conductors; second, electrolytes, so called because they may be decomposed by passing electric current through them, are poor conductors; third, resistance, bad conductors or good insulators consist of such well-known materials as rubber, glass, ebonite, shellac, mica, etc.

Complicated Smoke-Stack Connection

The new 22-story Consumers' Building, State and Quincy St., Chicago, has an 8½-ft. asbestos-lined steel stack in a shaft at the rear of the building. This stack, 301 ft. high above the street, was originally intended to serve a heating plant in the building, but later service was secured from a plant in the Baltimore Building, an older eight-story structure at the rear.

In the basement of the Baltimore Building is one of the heating plants of the Illinois Maintenance Co., which supplies steam for heating throughout the block and also for the Fair, a large building occupying the adjacent



Connection between an Outside Smoke-Stack and an Inside Smoke-Stack at Two Adjacent Buildings in Chicago

block. The smoke flue from this plant extends in the building only to the third floor, where a connection is made to an unlined outside steel stack supported on cantilever brackets. It was realized that with this large power plant it would be impossible to control the smoke to such an extent that it would not be obnoxious to tenants in the higher adjacent Consumers' Building, while it would soon blacken the white glazed terra-cotta facing of the rear of that building. In order to forestall these difficulties the Illinois Maintenance Co. made arrangements to connect its outside stack on the Baltimore Building with the inside stack of the Consumers' Building.

The arrangement and the details are shown in the illustration. As the two stacks are not in line the connection is inclined from north to south as well as from east to west. A special feature of the construction is that the connection (which weighs about 11 tons and extends across the alley) is supported from the framing of the Consumers' Building, so that no part of its weight is carried upon the lower stack. The bottom of the connection simply telescopes into the latter stack, a flashing being arranged in the joint. This allows free expansion and contraction of the stack, while in case of fire and the fall of the walls of the Baltimore Building (a nonfireproof structure) the stack would drop away without affecting the Consumers' Building.

The connection between the two stacks is a shell 8 ft. 10 in. diameter, with an elbow at each end. The bottom elbow enters the top of the shorter stack, and the upper elbow connects to the side of the stack in the Consumers' Building. The weight is carried by $1\frac{3}{4}$-in. hangers with 2-in. pin attachments to brackets on the stack connection and pin plates on the columns of the building, as shown in Fig. 2. The lateral thrust is taken by a pair of horizontal box-lattice struts bearing against the columns of the building at the level of the 14th floor.

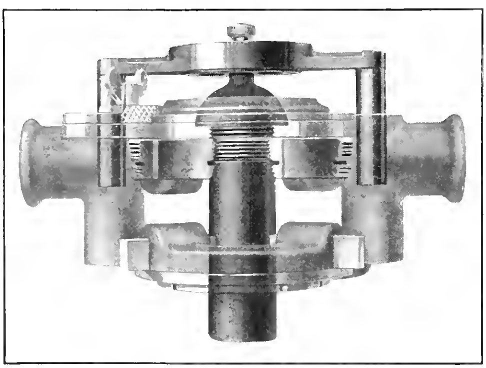
The design for this stack connection was made by Mundie & Jensen, of Chicago, architects for the Consumers' Co. Building. The steelwork was built and erected by the Hansell-Elcock Co., also of Chicago.—*Engineering News.*

Beaver Crossbar Die Stock

The Beaver crossbar die stock, manufactured by the Borden Co., Warren, Ohio, differs from other die stocks in several important features.

A bar extends across the top of the tool, carrying a plug which rests on the end of the pipe. The dies are made in two sections. The lower one does the rough work of starting on the pipe with teeth especially formed for this purpose. The die remains stationary during starting and after the upper section begins to cut this lower die gradually withdraws from the pipe, until it no longer touches, as shown in the illustration.

The upper die is a narrow receding die and constantly opens as the thread is cut, producing a perfect standard



Beaver Crosshead Die Stock

pipe thread. These dies have the further advantage of following the partial threads cut by the first section, which reduces the labor and insures a correct thread pitch without a leader screw.

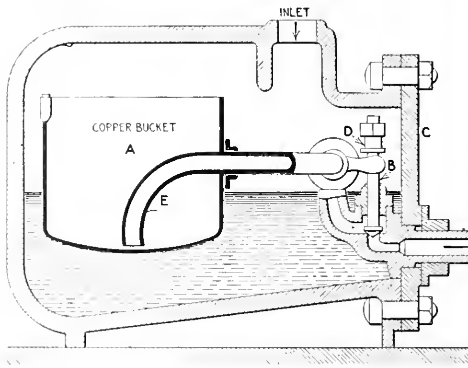
The principle involved is as follows: A swiveled plug extends down between the dies to the bottom of the upper section in starting. The pipe is started and threaded as usual. When the work of the lower stationary die is completed the pipe end comes in contact with the swiveled plug, raising it as the second set of dies cut the thread. Raising the plug lifts the side posts, turns the engaged die cam, and gradually opens the dies at the pipe taper until the thread is completed, when the dies are released; there is no backing off.

The operation of the tool is simple. The dies are set by the handle shown, and the pipe is threaded without the attention of the operator. To cut another thread the crossbar is simply pushed down, which re-positions the tool. The body of the tool is made of practically one piece with wide openings to allow chips to get away and for free oiling facilities.

A universal guide centers all sizes $\frac{1}{4}$- to $1\frac{1}{4}$-in. The tool is regularly furnished with double-ended, reversible dies $\frac{1}{2}$- to $1\frac{1}{4}$-in. Extra $\frac{1}{4}$- by $\frac{3}{8}$-in dies can be furnished, also all sizes of dies, either right- or left-hand.

Dinkel Steam Trap

The Dinkel steam trap, illustrated herewith, employs an open, copper-float bucket *A*, a valve *B* and connections, all of which are inside the trap chamber. The valve is held closed by its own weight and the pressure



Section through the Dinkel Steam Trap

within the trap chamber, and is opened by an increased pressure exerted upon it by the action of the float. As the working parts are attached to the end plate *C*, they are easily removed.

As water fills the trap chamber it raises the float until it strikes against the top of the chamber. As it can go no further the water continues to rise and overflows into the bucket, which, when full, sinks to the bottom of the chamber. This action brings the projection of the lever arm against the thimble *D* on the top of the valve stem and lifts the valve from its seat. The water in the bucket and that above the top of the bucket is then discharged through the connection *E* and through the valve. When the discharge ceases the bucket rises until it floats and the valve closes.

A body of water is always left above the valve seat after each discharge, which prevents the escape of steam.

This trap is manufactured by the Flushovalve Co., 536-538 Broome St., New York City.

Editorials

Government Fuel-Test Reports

The coal that produces the largest net returns per dollar invested is the coal to burn. If the right kind of furnace is not under the boilers to burn the coal used, it is good business to put in that furnace and make all other necessary changes.

All of the various grades of coal mined in the United States must be and will be burned in some way or other, and it is the engineer's part to burn it with the greatest economy, both for the sake of the owner and for coming generations.

To burn coal with maximum efficiency, exhaustive tests have been and are being made by competent engineers under United States Government supervision. By studying their reports one can decide with certainty on the kind of grate and setting to install. To make such tests oneself would be out of the question, because of the expense. Government reports should be studied.

It Is the Little Things

"It is the small details which go toward making perfection; and this last is no small thing." An artist said this when asked why he was taking such care in the representation of a familiar object forming but a minor portion of the work under his hand. What he replied is a truism, something we are inclined to admit in the abstract and prone to forget in the concrete. Perfection, one-hundred per cent. efficiency, is the unattainable; yet that should not and does not usually prevent striving for that goal. But what is it that stands in the way, barring the attainment of perfection? Just a little thing, the small fractions of that last one per cent. between the attainable ninety-nine and the unattainable one-hundred. Small and insignificant in themselves, those figures that represent the gap are the wondrous monument that marks the progress of the world, of science, of engineering, of chemistry. They are the fruit of the toil and the study of the ages. Looking back upon the methods of a few years ago with the searchlight of today, it is difficult to remember that, in their time, those methods formed the apex, that those who strove to surpass them were pioneering in the same way as those who now strive to pass the mark.

Today, as yesterday, all of the works of the world are but aggregations of the small details, their components; and none of them is without significance. And as the great work stands as the monument of its builder, so does each of its components. Each small detail as it lacks perfection contributes to the imperfection of the aggregate, and still more will it detract if, inherently imperfect, its functions have not been properly coördinated with the other components. Just as the weakest link governs the strength of the chain, so is the validity of any structure dependent upon its weakest component. In itself of little account and of small moment, when located at a strategic center it becomes the keystone of the arch. If it fails, then the deluge and the storm, the wreck; and then, sometimes, rebuilding.

All the lessons of the ages are bound up in a few words, easy to remember, easy to forget. But to those who can read their story it is written in letters of flame, "Forget you not of the details, nor of the end thou wouldst attain."

Examination

The safety of life and property demands that only careful, experienced men shall be allowed to operate steam plants.

The temptation to hire cheap help or to give a deserving friend a job is too much for many employers. They welcome an excuse which enables them to send the importuning candidate to some disinterested board or commission, with instructions to get a license or to get placed on a civil-service list.

But how is this disinterested board to find out if the man is qualified?

Most such boards have members who are educated, in the common sense of the word—that is, they have been to school. An examination to them means a written test in which all the candidates are asked a given set of questions on which they are marked like so many school children.

If they stopped to think, they would realize that it is nearly impossible to get up a single examination that will tell a true story of the candidate's fitness. When it is necessary to offer examinations every few weeks, each of which must be different from those which have preceded it, the problem becomes wholly impossible of solution along these lines. The result is that a few questions are thinly disguised and made to answer for a series of examinations. Shrewd men can pick out the few questions and see through the disguises, and armed with the knowledge that there will be little variation, they coach men who are normally unfit, so that they can get licenses. Likewise, it is just as necessary for the men who are fit to take this same coaching in order to pass, for the questions of necessity have little connection with the everyday practice of their trade.

How the essential qualities that make a successful engineer can be truly judged except on the job has always been more or less of a puzzle to us. What a man will write as an answer to a question dealing with a blown-out tube, and what the man will do when confronted with the actual accident, are two different things. It is very much like training soldiers by giving them written examinations. Instead of that, they are drilled until their work becomes automatic and their officers know that as a matter of habit they will obey orders and obey them in the same way every time.

Just so an engineer should be trained so that if he hears the sound of escaping steam in any direction he will unconsciously do the right thing, and do it at once. It is better for him if he understands the reason why and does it intelligently, but as a matter of safety the important thing is that he shall do it without stopping to think.

The question of the competence of the man to produce the maximum amount of service from the minimum of coal is also something that can be told only on the job, and in which he can be trained only on the job. No amount of questioning, nor even of preparation for examination, will add to the power produced per pound of coal, nor will it give much of a line on what the man will do once he gets on the job.

We suggest to the various legislatures which are annually struggling with this problem, that they investigate the means of training engineers in safety and efficiency and then fit their laws to what is possible.

Safeguarding the Bus Room

Close scrutiny of the arrangement of busbar compartments in a number of power stations indicates the desirability of paying more attention to safety features in laying out and operating this important part of the plant. In high-tension installations adequate space is generally conceded to busbar and oil-switch equipment, for the two are closely related and there is economy in copper where short and symmetrical connections are possible between disconnecting devices and busbar sections. It is the good mechanical job that best serves the needs of a high-tension gallery or switch room, and straight, simple runs of wire or copper tubing, combined with what might be called a clean-cut switching arrangement without complications in its apparent relations to the circuits, generating units, transformers and busbars, make one of the best possible designs.

In lower-voltage work it is not uncommon to find the space assigned to switches and busbars cramped in the extreme. Week after week these portions of the equipment stand the demands of service without a "hitch," and then, without an instant's warning, a heavy short-circuit on the distribution system or possibly on some interstation tie line, backed up by the generating capabilities of perhaps half a dozen units, transforms these compartments into a spectacular sample of the lower regions. The manner in which arcs backed by ample generating capacity will at times communicate to neighboring switch cells, accompanied by the carbonization of cable insulation, need not be detailed here, but the initiated appreciate the wisdom of allowing plenty of space in passages around such compartments and of using barriers of substantial thickness in providing accommodations for this sort of equipment. To the casual visitor to a plant the allotment of liberal space to busbar and switch mechanism housed in by concrete or other barrier construction appears almost needless, but when operating emergencies occur plenty of elbow room is invaluable.

Too little attention has been paid in many plants to the lighting of such rooms by permanently installed lamps wired in conduit and controlled from outside the room itself, and often, where permanent lamps are used, the sizes are too small for throwing the necessary light into recesses of cells. Moreover, it is petty economy to install a low-powered unit without a suitable reflector in this part of a station. Switch mechanism is almost always painted black with asphaltic compound, and the point is worth looking into whether it would not pay in some cases to use white enamel paint or a judicious combination of the two, in order to make the adjustable parts and points of lubrication stand out more prominently.

In stations where two or more men are on duty per shift it would not be a bad plan to provide outside the bus room a pilot lamp which will show the presence of anyone within, and in not a few stations too little care is taken in admitting visitors to this part of the building. If there is any place in a station outside the main operating and boiler rooms where first-class lighting, ample space, local telephone service and dual means of exit are desirable, it is the bus room.

The Noise Question

Present-day engineers, machinists and others who work in the midst of noise seem to regard it as a necessary evil. Pump operators who are working beside noisy, nerve-racking metal gears—so clamorous that it is impossible for them to hear spoken words without having them shouted into their ears—should look about for means to reduce the din. These noises can be lessened if not totally eliminated.

It has been demonstrated repeatedly that when harassed by noise the average man cannot concentrate on his work as well as he can in quiet surroundings. Then why not make shop and plant conditions favorable to maximum work and production by cutting out all unnecessary noises?

It is difficult to make workers in offices consider this problem, because there is comparatively little noise in an office. Office men who once worked in noisy places should appreciate the difference and be keen to take advantage of every possible point helpful to the highest economy and maximum production, and at the same time if they wish to do a good turn for humanity they will do all in their power to promote quietness for their subordinates who are now compelled to put up with disagreeable surroundings.

Quietness is a factor of efficiency that is too frequently completely overlooked.

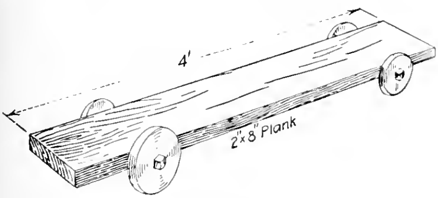
One of the greatest benefits of classroom lecture or lodgeroom study, as against self-education by solitary study, is the spoken word when correctly spoken. In classroom recitation or discussion the free and familiar use of terms becomes a habit, while in study at home the utterance of the same terms may be only at rare intervals if at all. Should occasion arise for comparison, which will "show up" to the best advantage, granting an equal knowledge of the subject matter? Unless words and terms are used with assurance they cannot carry the weight of conviction and will, therefore, serve to defeat the object of their use. A splendid exercise for the lodgeroom is the use of a good pronouncing dictionary, every fellow to take a turn at the definition and pronunciation of words and engineering terms more or less commonly used. Many perfectly good words will go lame and be so disguised by improper accent as to be hardly recognizable.

The prompt adoption by the Ohio Board of Boiler Rules of the Code of Specifications for the design, construction and operation of steam boilers and other pressure vessels is very gratifying. It is hardly believable that either inertia or opposition can long prevent its universal enforcement.

Correspondence

A Handy Car for Inside of Boiler

The illustration shows a handy device for the boiler cleaner or inspector. We used a 2x8-in. oak plank 4 ft. long and beveled the ends on the under side. The wheels used were old worn-out valve disks from a feed



Boiler Cleaner's Car

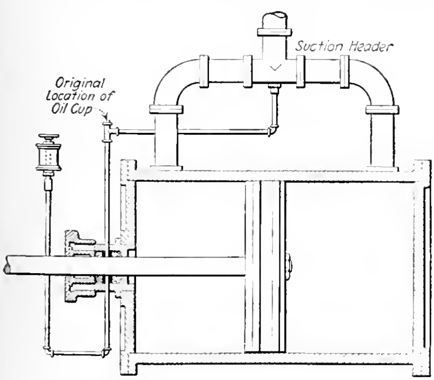
pump put on with lagscrews about 6 in. from the end, as shown. In this way we have a car that can be propelled to the back end of a boiler in a jiffy and we can come out dry.

A. C. Chrisman.

Girard, Ill.

Lubricating Compressor Piston Rod

The stuffing-boxes on two ice machines in a small refrigerating plant gave considerable trouble. Unless three or four times as much oil as is usually needed was supplied, the rods would either run hot or leak and the pack-



Lubricating Ammonia-Compressor Piston Rod

ing would soon wear out. It was difficult to keep engineers for a time after the plant was started, and most of them kept out of trouble with the ammonia rods by using excessive quantities of oil.

Finally, a man came along that stuck to the job. As soon as he was settled he turned his attention to the ammonia rods. The oil-cup connections to the stuffing-boxes struck him as peculiar and not according to the best practice, so he decided to change them.

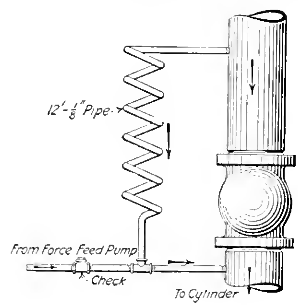
The sketch shows the oil cup in the changed position and also shows its original location. The machines were of the horizontal double-acting type. In this machine there is usually more or less gas escaping through the connection to the suction line. With the original connection the escaping gas carried much of the oil along with it into the suction line and into the system; in fact, the system was loaded with oil, as was found later. Connecting the oil cups to the under side of the stuffing-box overcame this defect and thereafter a small amount of oil was needed.

Thomas G. Thurston.

Chicago, Ill.

Condensing Coil on Oil Feed

At the request of an oil salesman we experimented with a 1/8-in. copper coil 12 ft. long in connection with the force-feed lubricator, the object being to break up the



Condensing Coil as Connected

oil by the addition of a little moisture. The steam pressure carried was 140 lb. gage, superheated to about 440 deg. F.

The result was so surprising that we think it will interest the readers of Power. With the same amount of oil formerly used the valves appeared to stick. Doubling the quantity of oil took care of that trouble, but the piston became noisy and developed a decided pound at each end after a 12-hr. run, and it was decided the steam-ring springs were too stiff. New springs were put in, but this did not stop the noise.

An examination 12 hours later proved the lubrication was deficient, and there was no vestige left of a glaze on the cylinder wall of six years' standing. The oil atomizer was removed, and the engine again operated with the original amount of oil with the most gratifying results. The question is, what effect does the superheat (80 to 100 deg. F.) have on an emulsion of cylinder oil and water? The oil is a standard high-grade article made from Pennsylvania crude and for superheated steam. The object of the condenser coil was to cut down the amount of oil used or to substitute a lower grade.

C. H. Reed.

East Chicago, Ind.

Metallic Packing for Valve Stems

About a year ago it became necessary to renew the metallic packing on the Corliss type valve stems of a large pumping engine. To get a tight job with such packing it

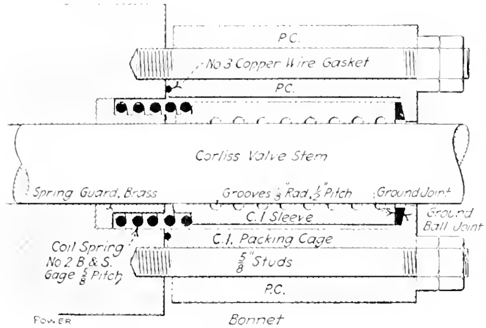


Fig. 1. With Packing Case

is necessary to take great care in truing and grinding the rings and ball washers, and the job is expensive. The superintendent objected and said: "We want something we can make ourselves; it is up to you to dope out a design that is simple, steam-tight and cheap." My first attempt is shown in Fig. 1. I don't pretend to be able to say what happens in the grooves and nozzles, but the steam is so busy chasing itself in and out of the grooves that little finds its way to the end of the sleeve.

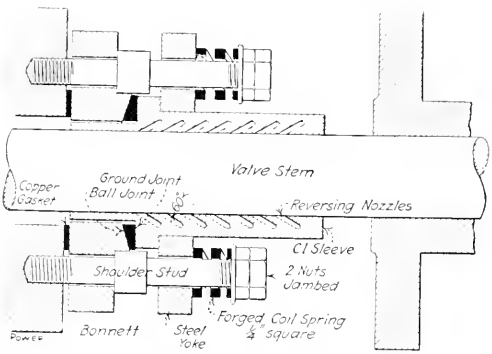


Fig. 2. Modified Form

Fig. 1 is on the exhaust valve stem of a high-pressure cylinder working steam at 200 lb. pressure. It was put in on Feb. 10, 1914, and has run 24 hours every day since and is practically steam-tight.

Fig. 2 does away with the packing case and need not fit the stem so closely. It is best for stems that do not run true. Fig. 3 is now used on the low-pressure exhaust valve stems and is sealed with steam from the low-pressure receiver at 6 lb. gage through the pipe shown, or in other cases this may be used as a drain pipe.

For all other stems the nozzles all point toward the

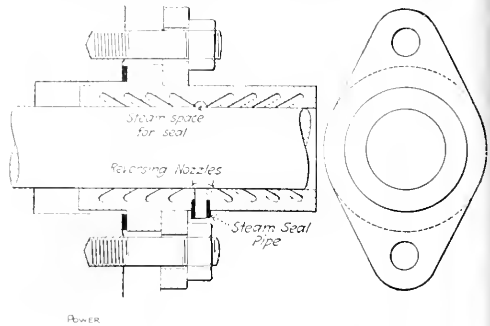


Fig. 3. Low-Pressure Type

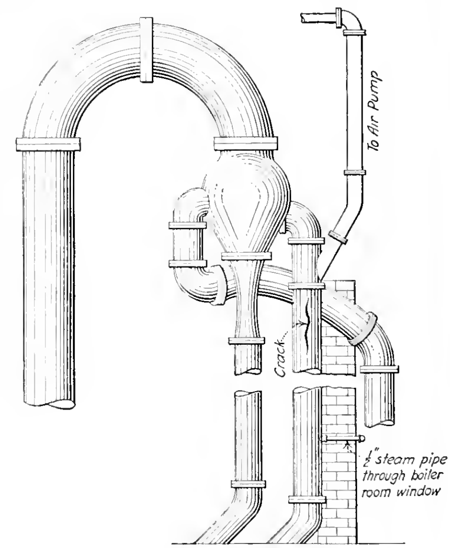
valve. If anyone is interested in the details of the machine work I will be glad to supply them.

S. H. Farnsworth.

Chicago, Ill.

Vacuum Pipe Repaired

Early in the forenoon one day last winter I discovered the vacuum had dropped from 28 to 27 in. and was still going down, and when we shut down at noon it had reached 25 in.



Condenser Pipe Split

Such unsatisfactory vacuum denoted something wrong, so I investigated the outside piping of the barometric condenser and found a crack 4 in. long and 1/4 in. wide in the overflow pipe about 25 ft. from the ground. To avoid a shutdown before the end of the week various schemes were tried. First, the millwright filled the crack with waste and covered this up with brown paper shellacked to the pipe, then tried sheepskin, but that also was disappointing. Glazier's putty was next tried and it held. This soon brought the vacuum to 27 in., but it had to be renewed every day.

The plumbers were finally given the job of putting on Smooth-On cement for a permanent job. We then saw what had caused the pipe to burst—it was full of ice—and to prevent its recurrence, a small supply of steam was piped in to keep the water above the freezing point. I wrapped canvas round the pipe from top to bottom of the crack in the shape of a bandage, then had it painted over.

It is about a year since this happened and the vacuum is as good as it was before the pipe was ruptured.

Charles Sword.

Cohoes, N. Y.

Connecting Resistances

When all the terminals of a resistance and the corresponding controller fingers are numbered and the resistance boxes are the same in number and of the same relative size as the ones indicated on the controller-connecting diagrams, then the procedure of connecting the devices is a simple matter. On controller prints, however, the resistances are often so indicated as to make it difficult for the uninitiated to identify corresponding sections and points of the conventional print and of the resistance boxes as received.

A mill operator who was familiar only with continuous-current operation, installed a three-phase, slip-ring induction motor to drive the cylinders for the glazing of gunpowder. His print gave the connections as indicated

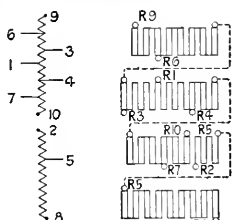


FIG. 1 FIG. 2

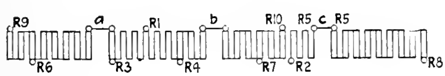


FIG. 3

Figs. 1 to 3. Diagrams Representing Resistance Connections

in Fig. 1 and the resistance boxes as received were in four units, or boxes, as in Fig. 2, in which it will be noted that all the terminals intended to receive controller wires are numbered accordingly, but that the end terminals are not numbered unless they are to receive controller wires. Thus, in Fig. 2, the top box has one unmarked terminal; the next, two and the third, two; and apparently there are no wires to fill them. The unmarked terminals are for the jumpers that connect the several boxes together. On a less involved resistance layout, the object and the manner of realizing it would be more evident. In the present case, the correct location of the jumpers was obtained as follows:

It was noted in the sketch (Fig. 1) that from R_1 one path led to the left through R_3 and R_6 to R_9, and that another path led to the right through R_4 and R_7 to R_{10}. Accordingly, the box with R_1 in the central part, with R_4 to one side and R_3 to the other, was placed upon the floor. It was plain that the next box to be handled had to have R_6 or R_7 in it; therefore, the R_6-R_9 box was laid end-on to the box already placed. As Fig. 1 showed the marks to progress toward the higher number, the second box was placed with the R_6 toward the R_3. Installing jumper *a*, as in Fig. 3, then gave a continuous path from R_1 to R_9. The third box with R_7 and R_{10} in it was then placed end-on to the first box, so that by employing jumper *b*, a continuous progression from R_1 to R_{10} was had. This completed what seemed to be a single long box in Fig. 1, but which was really two boxes and part of another.

There was now only one more to handle and only one place for it. One end was marked R_5, as was also one end of the last box handled. As the latter box had insulation washers that divided it into two parts, it was so placed as to bring the two terminals marked R_5 together; these were then connected by jumper *c*, which gave an independent path from R_2 through R_5 to R_8, just as in Fig. 1. The coils were then marked 1, 2, 3, 4, the jumper connections marked for identification and the boxes placed one above the other in their marked order. It was then noticed that the nameplates were numbered, and if the boxes had been assembled in the order of those numbers in the first place, the positions of the jumpers would have been evident, as the nameplate order was the same as that worked out.

J. A. Horton.

Schenectady, N. Y.

Putting New Headers in Water-Tube Boilers

In most boiler rooms, the renewal of burnt-out or broken headers in horizontal water-tube boilers is a long and hard job. The following method, requiring little skill and small expense for special tools, has been successfully used.

Two 1-in. steel rods are needed, each long enough to reach from the outside of the front header through the tube to the outside of the rear header, leaving about six inches surplus on either end. Both ends are threaded and fitted with heavy square nuts.

The water tubes, circulation tube and mud-drum nipple are carefully crimped inside the header with an ordinary crimping tool. The header is raised sufficiently to free the mud-drum nipple, by using a crowbar and blocking up with wood blocks. If the tubes have been crimped sufficiently, little trouble will be experienced in drawing the header from the tubes. Some of them may stick occasionally, however, and then one of the rods is run through the tube and used as a battering ram from the other end, knocking the inside of the header and tending to knock it away from the tubes. After it has been loosened in this manner, a slight downward pull will remove it from the circulation tube.

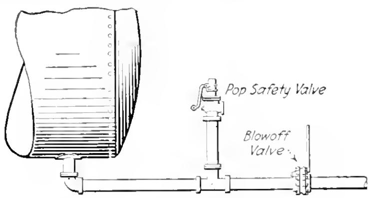
One of the rods is then put through one of the top tubes and the other through one of the bottom tubes. Each rod is run out through the handhole on the other end and, if the boiler is of inclined-header type, through one of the ordinary handhole caps so that the turning-nut will have good bearing surface. If the boiler is of the vertical-header type, the handhole caps cannot be used, as they are not set in alignment with the tubes. In this case, pieces of ½-in. iron faced with a wood block to prevent damage to handhole faces must be used. The new header is then fitted into the circulation tube and brought as nearly into position as possible, with the ends of the rods protruding out through the handholes. The caps are fitted over the rods and the nuts put on. Then, by simply tightening up on the nuts and guiding the other tubes into place, the header is drawn up into position and placed over the mud-drum nipple. The tubes are then ready for rolling and flaring, after which the rods are removed and the boiler is again ready for service.

R. T. Gray.

West La Fayette, Ind.

Preventing Water-Hammer in Blowoff Pipe

The illustration shows a scheme to prevent blowoff failures from water-hammer. An ordinary pop valve is placed between the boiler and blowoff valve on a short riser, to prevent scale from lodging under the valve seat.



Safety Valve on Blowoff

The pop should be set about three pounds heavier than the safety valve on the boiler. On vertical boilers having a greater head of water in the boiler, this will have to be increased to correspond to the head of the water above the valve. The area of the pop should be equal to the area of the blowoff pipe.

Charles Fenwick.

Wapella, Sask.

[There would appear to be objection to the foregoing, because the boiler might be drained of water if the safety valve on the boiler should be slightly sluggish or stick at some time. Also, the man blowing down might be scalded if not carefully protected.—Editor.]

Oil-Engine Piston Trouble

A short time ago I was called in to locate, if possible, the trouble with an 11x9-in. two-stroke-cycle oil engine. It had recently been installed and was built by a steam-engine company that had entered the oil-engine field. The engineer's explanation of the trouble was that, after starting, the engine would run for about a dozen revolutions and then stop and was even much harder to turn over by hand than when cold.

The engine was one of the hot-ball semi-Diesel types with a long piston. Upon examination I found that the piston diameter was 0.01 in. smaller than the cylinder bore when both were cold, and when heated the head end of the piston expanded more than the cylinder and stuck. I turned the piston down to $\frac{1}{32}$ in. smaller than the cylinder bore, both being cold, and the engine operated satisfactorily. It might be well to add that many oil-engine builders do not allow sufficient side clearance between the piston rings and the grooves, and as a result the rings soon bind and become ineffective, due to carbonization, etc.

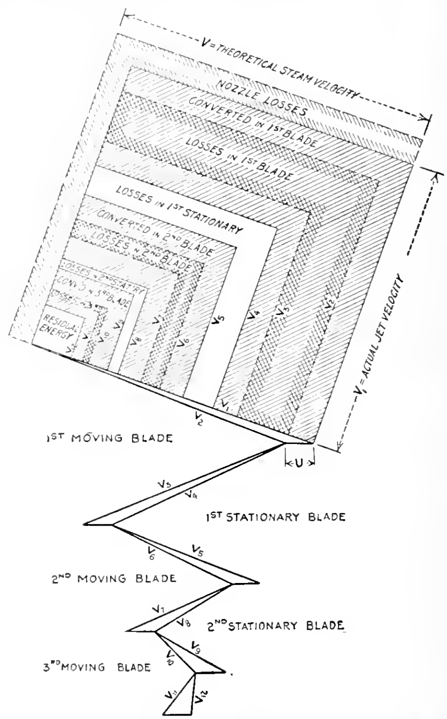
M. E. Griffin.

Franklin, Penn.

Steam-Turbine Diagrams

Mr. Low's article on turbine-velocity diagrams, May 4 issue, considers only the theoretically perfect turbine, when there is no friction or other losses.

It occurred to me that it might be worth while to go a step further, so I have plotted the actual-velocity diagram of a small single-stage turbine having three rows of moving blades. The bucket speed is 225 ft. per sec. The steam is supplied to the nozzles at 160 lb. per sq.in.



Velocity Diagram for Single-Stage Turbine

absolute and expanded therein to atmospheric pressure. The theoretical steam velocity resulting from this pressure drop is equal to about 2920 ft. per sec., but losses in the nozzles reduce this considerably.

The other losses shown are the friction and eddy losses, etc., which occur as the steam passes through the blades. These are proportionally very large in a machine of this size, because the attempt is made to utilize the large energy drop in a single stage. Besides this, the coefficients of loss in this case have been taken well down.

The figures show that about 40 per cent. of the energy of the steam is converted into useful work. This is represented by the areas shown in simple cross-sectioning. And the water rate of such a turbine would be approximately 40 lb. per horsepower per hour.

PARKER M. ROBINSON.

New York City.

Difficulty in Rotating Piston to Unscrew the Rod

Not long ago I found it necessary to remove the crosshead from a 16x18-in. engine in order to babbitt the shoe. Arrangements had been made at the shop for this work to be done on the following day, and as it was necessary to keep the engine running as long as possible, about an hour's time was allowed to take the crosshead out. The $2\frac{3}{8}$-in. piston rod was screwed into the crosshead about $3\frac{1}{2}$ in. It was known to be an easy fit and no difficulty was anticipated.

The start was made quite easily, but the second quarter turn and every turn for the full length of thread was about all that two men could pull on a four-foot bar. After the first few turns I concluded the trouble was due to the piston rings. There were six cast-iron eccentric snap rings $\frac{3}{8}$ in. wide and about $\frac{5}{8}$ in. deep, tapering to $\frac{7}{16}$ in. at the joint. These rings were doweled to the piston, so that when turning it was necessary to turn them also, and the force being applied to their ends caused them to expand and greatly increase the friction.

This was relieved considerably by turning the engine slowly and turning the piston at the same time. Under these conditions it took nearly four hours to unscrew the rod. The reason this difficulty had not been encountered before on this engine was because the rings had been doweled when the cylinder was removed to make other changes and the cylinder had been slipped off and back on over the piston.

E. P. HAINES.

Baltimore, Md.

Gas Explosions in Boiler Furnaces

Mr. De Blois' letter in the April 20 issue, page 553, regarding his experience with a gas explosion in a boiler furnace, and the letters of comment thereon are highly interesting. The writer's experience, covering many gas explosions of various kinds, leads him to offer another explanation as to the cause.

Taking the conditions as they existed: The ashpit doors were sealed, which would mean that no air could reach the fuel except from the tuyeres or through the door. The boiler was being forced and the coal fed rapidly. From this we must assume that the furnace was more than usually hot and that there was a large quantity of green coal on the side on which the door was closed. As there was no possibility of air getting to this coal from below, it would be subjected to destructive distillation with the consequent evolution of a large volume of gas of a high calorific value. This gas, undiluted with air, would be drawn by the stack draft through the setting, mingling with the air and possibly burning in the rear of, or beyond, the setting. (It is quite possible for two streams of gas and air to exist in adjacent and clearly defined areas, without forming an explosive mixture, particularly if moving in one direction.) The sudden admission of a large amount of air caused a disturbance that resulted in the breaking up and intermingling of the gas and air stratas and the instantaneous formation of an explosive mixture. From the violence of the explosion it would appear that the explosive mixture had filled the setting before ignition took place.

As to preventive measures, one can only suggest that under similar circumstances the other fire-door be left slightly open, to allow sufficient air to burn whatever gas is being formed. The writer would like to know the style of setting, the nature of its connection to the stack, and the amount of stack draft at the fire-door.

S. M. QUINN.

Detroit, Mich.

Commenting on the letter by L. A. De Blois, on the subject of gas explosions in boiler furnaces, it seems that the information given in response to the inquiry sent is not conclusive. Obviously, however, the explosion was due to an improper gas mixture. The writer believes that the importance of proper regulation of draft to meet changes in load has not been given as much attention as it deserves. Most manufacturers of damper and fan regulators emphasize the sensitiveness of their apparatus. Regulators of the open-and-shut, or noncompensated, type are inherently sensitive and will, if in good working order, cause a complete travel of the damper or fan-regulating valve with a slight change in boiler pressure, sometimes under 1 per cent. The writer is of the opinion that, while such regulators make a good-looking record on a pressure gage, their use is rarely justified, and this for the reason that it is not good practice to force a fire of either anthracite or bituminous coal up to brilliant incandescence and then shut the draft off entirely or merely leave the draft due to a short stack. Regulators of the compensated type which cause only partial travel for slight changes in steam pressure are better, but in general they are not compensated enough to prevent results somewhat similar to those produced by the open-and-shut type. Compensated regulators, as received from the manufacturer, will generally give complete travel with steam-pressure variations of less than 2 per cent., and in many plants where the load variation is frequent and considerable this practically amounts to open-and-shut regulation. This type of regulator also makes a good steam-pressure record.

While criticizing the use of such apparatus, the writer is most emphatically in favor of the use of automatic regulators designed so that a considerable variation in pressure will be required to cause total travel of the damper or fan-regulating valve. In most plants a variation in steam pressure of 5 or 6 per cent. is not objectionable, and a regulator which is compensated to require as much variation as this for total travel will subject the fire to much less fluctuation in temperature and in gas composition than a regulator of the type mentioned above. The steam-pressure chart, however, will not be as near a true circle as with the other type; but the charts from the CO_2 recorder will be uniformly higher, and the furnace economy will be perceptibly better.

Emphasis should also be placed upon complete automatic regulation as against a makeshift device such as mentioned in one of the letters published. A control which requires frequent juggling by the attendant in order to make it cover the requirements is unsatisfactory, because no two attendants have the same ideas and many of them have wrong ideas as to the proper control of draft.

The writer appreciates that the statements made may not apply directly to the conditions described by Mr. De Blois and does not feel qualified to express any opinion as to the probable cause of the accident. There is, however, a point in the design of boiler-flue dampers which should not be lost sight of; that is, that a flue damper should be made short enough so that when it is in the extreme closed position there should be a considerable percentage of opening either at the ends or around the outside edge of the damper. Most manufacturers provide this, but the percentage of opening seems to vary considerably with different makers. I believe that gas explosions, which occur so frequently when banked fires are suddenly put into service, are often due to a lack of sufficient space around the flue damper. This is an interesting and important question, and I hope that it will be thoroughly discussed in POWER.

D. L. BELLINGER.

Glens Falls, N. Y.

In the issue of Apr. 20, page 553, L. A. De Blois gives an account of trouble from gas explosions in a boiler furnace and he invites comment. The installation consisted of three boilers connected to one stack by a breeching, each boiler being fitted with an underfeed stoker. A fire-door was provided on either side of the stoker in each boiler front. One engine-driven blower was connected to the three stokers. It is not stated what type of blower, but I assume that it is of the fan type. It is assumed that the boilers are set in brick and also that there are dampers in the throat connections between the boilers and the breeching.

One boiler only was being operated, the others presumably being cold. Usually, steam is carried on two at a time. The main-stack damper was open and the ashpit doors were sealed. Consequently, the only regulated air inlet is through the blower duct and through the fire-doors when open. The boiler was being forced, and the stoker was feeding coal rapidly. The fireman opened one of the fire-doors and removed a clinker which obstructed the blast tuyere. On the removal of the clinker a gas explosion followed, injuring the fireman. The stack clean-out door was blown open.

We may assume that the explosive was of a mixture of CO and other gases with air. Further reference to other combustible gases than CO will be omitted. If combustion were perfect there would be no CO. If combustion is incomplete we have both CO and CO_2 in the escaping gases; and when the proportion of the CO to the CO_2 is about six to one we have a condition desired in a gas producer. When a fan-blower discharge pipe is closed or obstructed the quantity of air flowing is reduced. This condition is often met with in cupola practice. A tuyere becomes obstructed with slag, cooled by the blast; and until the slag is removed the flow of air is reduced and, consequently, the temperature of the bed.

If we are correct in our assumption of the quality of the explosive mixture, where does the mixture come from? Much coal is being fed into a hot fire; the admission of air is checked, CO is produced, and the temperature of the furnace drops. On opening the fire-door more air is admitted and the furnace temperature is further lowered. Probably, if nothing more were done at this time and the door were left open, there would be no explosion, as the increased draft would carry off the combustible gases. But if the air flowing in at the door and the CO already generated do not immediately make an explosive mixture, one must look for another air inlet. There remain two other possible sources—the throat dampers of the cold boilers and leaks in the boiler setting. Under proper forced-draft conditions there is one of two conditions in the boiler spaces—a plenum or a balance. Under either there will be little or no inflow of air through leaks. But there is no plenum and no balance, because the proper openings for the admission of air are obstructed and because the stack is trying to pull as the damper is open. There is a partial vacuum in the boiler spaces. My recollection is that tests carried out by Professor Breckenridge on a new battery of brick-set boilers at the St. Louis Exposition showed that the inflow of air through the settings was large, and that he mentioned a case in which the quantity of air so inflowing amounted to 30 per cent. of the total stack gases.

Assuming that air did flow in through the settings or through the throat dampers of the cold boilers, or both, there is a mixture of CO and air, and possibly in proportions necessary for rapid combustion. The temperature in the boiler spaces is comparatively low, the draft is reduced, and the gases are not promptly removed. There is now an explosive mixture awaiting some condition necessary to combustion. The fireman removes the obstructing clinker from the blast tuyere, intense heat and flame are produced locally, the flame and the explosive mixture come together, and an explosion follows.

I have said that the air flowing in through the open fire-door probably did not mix with the CO to form the explosive gas in large or dangerous quantity, for the reason given, and for this additional reason: In hand-firing fresh fuel is added through an open door, air also enters through the opening, but a heavy explosion does not always follow. Therefore, fresh fuel and an open door are not necessarily the cause of an explosion. Yet with heavy hand firing and checked draft, even in the case of internally fired boilers, there do occur "puffs," which are due to the rapid burning of a small quantity of comparatively confined gas. If there is a quantity of explosive gas in the boiler spaces, there will be explosion on the introduction of flame.

It may be suggested that I have not given a sufficient reason for the checking of the draft. Possibly there is another reason. The throat connection between boiler and the breeching may have been large enough for the normal rating of the boiler, but not quite large enough when it was steaming at much above rating. Again, when three boilers are connected by a breeching to one stack set at one end of the breeching, the cross-section of the breeching at the further end is usually calculated for one boiler at a little above normal rating. We do not know that the connections were arranged in this way, but we know that the boiler was being forced.

Because the foregoing is largely conjectural and inferential, I cite the following experience: In 1888 I was assistant engineer on some tests instituted in order that the best way to fire boilers with oil-gas might be learned. One of the boilers used was a two-furnace Scotch boiler. The furnace mouths were closed by removable iron plates.

Oil-gas and air were introduced through mixer burners; the oils experimented with were Astatki and American crude petroleum. These tests were made at North Greenwich, London, Eng. Oil from abroad was usually shipped in barrels. The Baku oil line had not then been built, and tank ships were not in general use. The tests were successful so far as evaporation of water per pound of oil was concerned, but were stopped when the price of crude petroleum jumped to 6d. (12c.) per gallon on the dock; the price of London steam coal being at the time 17s. ($4.08) per long ton.

The oil was vaporized in a producer by steam, in some tests superheated (with results which those who have tried it know), in others saturated, and in still others saturated with a later addition of superheated. We learned that a brick baffle before the burner or, better, around it was necessary. Pockets of water which were present in the oil of course gave no oil-gas; the flame went out; and when the pocket was exhausted and oil-gas again flowed from the burner the incandescent brickwork reignited the gas. It should be said that what we called gas was in reality a vapor and not a fixed gas.

On one occasion, soon after lighting off, the flame went out for a moment. The coverplates had not been put in place. An attendant threw a bunch of lighted oily waste into the furnace to ignite the gas when it came on again. But it had already arrived. The explosion was violent, and the brickwork in the combustion chamber (dry) was loosened. I had other proof of the force of the explosion, for I was standing immediately in front of, and only a few feet from, the boiler when the bunch of waste was thrown into the furnace. There was no other explanation than that the furnace and the combustion chamber were filled, the former partly and the latter probably completely, with an explosive gas. Did not the combustion chamber, breeching and stack base mentioned by Mr. De Blois contain an explosive gas? The stack clean-out door was blown open.

A later experience, and one more like that of Mr. De Blois, was as follows: About eighteen months ago I was asked to make an investigation and report on a case of boiler-furnace explosion. There were two boilers connected through a breeching to a brick stack, and both were hand fired. This fact is of some importance. When both were under steam firing was light and no trouble was experienced. To save fuel it was decided to try to use only one of the boilers at a time, holding the other in reserve, and cold. The fuel used was bituminous run-of-mine, with an occasional addition of wood shavings and sticks. A pile of shavings had stood on the boiler-room floor about ten feet from, and opposite to, the first boiler. On one occasion there had been an explosion, and flame had leapt across the boiler-room floor and had set fire to the pile of shavings. On the latest occasion, coal only being used as fuel, the fireman had covered the fire with a layer of rather fine coal. A little later he opened the door, and finding the fire deadened, stirred it with a poker or slice bar. Immediately, there was an explosion. The fireman was thrown across the room and was badly burned.

The manager of the plant argued that the cause could not be poor draft due to insufficient stack capacity, as this particular boiler installation had been in use for about twenty years and furnace explosions had been a recent experience. On examining the settings I found clean-out doors in the rear which could not be closed tightly (one could see about three-eighths of an inch of red light through the opening of the door of the live boiler); several large cracks in the brick walls; unnecessarily large holes in the walls where the water-gage connections and other pipes entered; open joints and empty rivet holes in the breeching; front doors not fitting closely. I advised that all setting leaks be stopped and the results noted. I heard of no further trouble. On reading Mr. De Blois' letter I called up the manager of the plant, and he told me that he had had the leaks stopped and that while there were little puffs or explosions now and then, they were neither as severe nor as frequent as they had been. Other running conditions were about the same as before.

I have said that the fact that the boilers were hand-fired was of some importance; it shows that explosions are not characteristic of stokers. The stoker was not necessarily at fault.

It is interesting to note that in this, as in Mr. De Blois' case, one boiler only was being operated. In this case it will be seen that there was no blast tuyere to become obstructed, but there was what amounted to the same thing—heavy firing with a close-lying coal, which obstructed the air passages through the grate and fire; and insufficient draft to pull air through the fire. There was also enough air leakage through the settings to make an explosive mixture with the CO and other gases generated, and there was sufficient local heat at times to fire the explosive mixture.

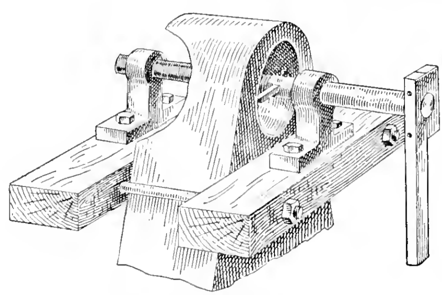
ARTHUR SCRIVENOR.

Richmond, Va.

Enlarging Crankpin Bore

When the crankpin of our ammonia compressor worked loose we decided to remove it, enlarge the hole in the crank and shrink in a new pin.

To do the job cheaply and quickly a 1⅝-in. shaft, 28 in. long, was threaded on one end with 30 threads to the



IMPROVISED BORING BAR

inch. A ⅜-in. hole was drilled through the shaft to carry the cutting tool, the latter being held by a setscrew. Two 4x4-in. wood blocks, each 2 ft. long, were clamped to the crank and each had a bearing for carrying the shaft of the small boring bar. The arrangement is shown herewith.

J. H. CUNNINGHAM.

Toledo, Ohio.

Grit in the Feed-Water Meter

Recently, the writer experienced considerable trouble with a Kennedy-type water meter. On opening it considerable fine coal grit was found. The puzzle was, how did it get there? The source of supply had not been changed, and this difficulty had never arisen before.

The overflow pipe from the injector had, temporarily, been put to discharge near the coal bin, and this pipe sometimes got covered over with coal when the bunkers were full. In this particular style of injector, a vertical one handling 23,000 pounds of water per hour, unless the correct amount of water is put on to suit the steam, a considerable suction can be felt at the overflow pipe, probably due to the check valve on the combining nozzle not seating tightly, so that it drew quite a little coal dust up the overflow pipe, discharging it into the feed line and meter.

E. R. Pearce.

Rochdale, England.

Influence of Ash Content

I read with interest Mr. Ellis' letter, "Influence of Ash Content of Coal," in the Nov. 3 issue.

High ash certainly cuts down furnace efficiency; on that point there is no argument. Mr. Ellis states that "coal apparently follows a straight-line characteristic as regards its value on a basis of its ash content, assuming the same character of coal." If by "same character" Mr. Ellis means any general class such as anthracite, semianthracite, semibituminous or bituminous, I take exception to his statement.

For a given coal I will concede the straight-line characteristic, but I do not see how one characteristic can be applied to all coals of the same character. For instance, in anthracites the heat of combustible or ash-free heating value, as it is sometimes called, varies from 14,400 to 15,200 B.t.u. With 15 per cent. ash, the B.t.u. dry in these limiting conditions is 12,240 and 12,920, respectively, a variation of 680 B.t.u. per lb. On this basis, it would appear to be advisable not only to keep the ash down, but to buy heat and not to accept the absence of ash as an indication of high heat. Low ash may or may not indicate high heat. The calorimeter answers that.

The formula at the end of the letter would, perhaps, have been better understood if an example had been worked out. As it stands, the "value of coal" increases numerically as the ash content increases, which is just the reverse of what Mr. Ellis stated. For instance, take a coal having an ash-free value of 15,000 B.t.u. and assume that two subsequent shipments show 10 per cent. and 20 per cent. ash, respectively. Assume the price delivered to be \$3.50 per ton. The B.t.u. of the first shipment are 13,500 and of the second shipment, 12,000.

The value of the first shipment by the formula is then

$$\frac{350}{13{,}500 - (13{,}500 \times 1.5 \times 0.10)} = \frac{350}{13{,}500 - 2025} = \frac{350}{11{,}475} = 0.0305$$

The second shipment shows a value of

$$\frac{350}{12{,}000 - (12{,}000 \times 1.5 \times 0.20)} = \frac{350}{12{,}000 - 3600} = \frac{350}{8400} = 0.0417$$

From this it appears that the worse the coal, the higher its value, as given by the formula. If it is correct, will Mr. Ellis state how much better he regards the first shipment than the last, based on the figures given by the formula?

Carleton W. Hubbard.

Brooklyn, N. Y.

Questions for Discussion

Gasoline Engine Run on Natural Gas

We purchased a gasoline engine that was taken out of a wrecked automobile. It is a 5x5-in. six-cylinder engine rated at 60 hp. when running at 1000 r.p.m. We are repairing this motor and intend to connect it through a flexible coupling to a 750-r.p.m., 17½-kw. generator to furnish power for our after-midnight load. The engine will be operated with natural gas and the speed controlled by a flyball governor mounted on the fan shaft and connected with levers and rods to butterfly valves in the air and gas intakes.

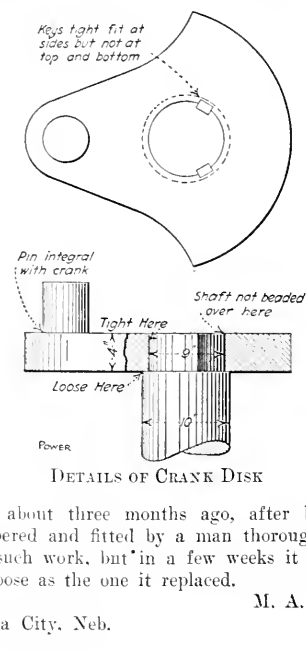
Have any readers of Power had practical experience with this type of engine operated on natural gas? If so, I should be glad to have suggestions as to how they have overcome the speed-governing problem, also as to what proportion of power the engines developed with natural gas in comparison with gasoline.

Erwiss Gawthrop.

Pittsburgh, Penn.

Loose Crank Disk

Can any of the readers of Power suggest some means of tightening a loose crank disk on a large high-speed engine without removing it? The disk was shrunk on the shaft about three months ago, after being carefully calipered and fitted by a man thoroughly experienced in such work, but in a few weeks it was apparently as loose as the one it replaced.



Details of Crank Disk

M. A. Jensen.

Nebraska City, Neb.

Inquiries of General Interest

Effect of Inside Lap—What is the effect of adding inside lap to a slide valve?

J. W. D.

By adding inside lap the exhaust port is closed earlier, thereby resulting in higher compression of the exhaust.

Corrosion of Steel Uptake—What would cause our steel stack and uptake to corrode more rapidly than formerly?

N. R.

Other things being equal, more rapid corrosion would take place from use of fuel containing more moisture or more sulphur, or from introduction of more moisture with the air supply to the furnace.

Slope for Drainage of Boiler to Blowoff—How much should the rear end of a return-tubular boiler be set lower than the front end for drainage toward the blowoff?

F. W. S.

Sufficient slope for drainage is usually obtainable for boilers 16 to 18 ft. long by setting the blowoff end about 2 in. lower than the front end.

Quality of Boiler-Feed Water—What proportion of scale-forming substances may be contained by a water to be considered as good or poor boiler-feed water?

L. G. N.

Water containing 8 to 10 grains of boiler-incrusting substances per gallon may be considered as good, while those containing 15 to 20 grains or more may be regarded as poor.

U. S. Navy Composition Metal—What is the U. S. Navy composition or steam metal?

J. M. C.

This is a composition metal consisting of 88 per cent. of copper, 10 per cent. of tin and 2 per cent. of zinc. Its tensile strength is about 32,000 lb. per sq.in. and its elongation about 25 per cent. On account of its strength and toughness this composition is considered superior for valves, flanges and other boiler accessories.

Danger to Cylinder from Sudden Overloading—Does overloading a cutoff engine have any tendency to blow out a cylinder head?

G. M. S.

In case of overloading, the higher velocity of steam in the steam pipes and passages has a tendency to suddenly sweep into the cylinder any accumulations of condensation and thereby endanger the cylinder and its head to rupture from presence of water in the cylinder.

Receiver of Returns Should Be Vented—Where a low-pressure heating system is supplied with live steam passed through a reducing valve and there is no vacuum pump on the returns, is it necessary to discharge the returns either to an open tank or into the atmosphere?

M. J. N.

Where the piping is properly arranged for drainage the returns may be collected in a closed receiver with an automatic air-relief valve, though it is better to supply the receiver with an air vent that is always in communication with the atmosphere.

Omission of Low-Down Tubes in Return-Tubular Boilers—In return-tubular boilers, why is not the space generally utilized for tubes on each side of manholes and handholes in the lower part of the flue sheets?

L. G. J.

Tubes placed low down in the flue sheets are not favorably located for receiving the flow of the gases from the combustion chamber and are thus of little value as heating surfaces. By their presence in the lower part of the boiler they not only displace a substantial amount of water which should be present to absorb the direct heat of the fire, but also impede circulation in a part of the boiler where it is most needed.

U. S. Navy Standard Boiler Compound—What is the composition of U. S. Navy standard boiler compound?

A. N. I.

This compound consists of calcined sodium carbonate, trisodium phosphate, dextrine or starch, and a tannin compound such as mangrove bark, cutch or catechu. These materials are intimately united by thorough digestion, dried, finely powdered, well mixed and readily soluble in water. The compound must show on analysis at least 76 per cent. of anhydrous sodium carbonate (Na_2CO_3), 10 per cent. of trisodium phosphate ($Na_3PO_4 12H_2O$), 1 per cent. of starch, and sufficient cutch to yield 2 per cent. of tannic acid, the remainder consisting of water and such impurities as are common to the ingredients.

Use of Iron in Place of Copper Feed-Water Tubes—A closed feed-water heater now fitted with copper tubes is capable of warming a uniform supply of boiler-feed water from 50 to 190 deg. F. To what temperature would the feed water be heated, using the same number and size of iron tubes?

J. H. B.

By the use of iron in place of copper tubes the rate of heat transmission would be about two-thirds as great as with copper tubes and the temperature of the water would be raised to about

$$50 + \tfrac{2}{3} \text{ of } (190 - 50)$$

or approximately to 143 deg. F.

Saving from Higher Evaporation per Pound of Coal—What percentage of fuel is saved with an equivalent evaporation of 9.5 lb. of water from and at 212 deg. F. per lb. of coal over an equivalent evaporation of 8 lb. of water per lb. of coal?

L. S. F.

With an evaporation of 9.5 lb. of water per pound of coal each pound of water requires $\frac{1}{9.5}$ of a pound of coal. With an evaporation of 8 lb. of water per pound of coal each pound of water requires $\frac{1}{8}$ of a pound of coal. Therefore, when the evaporation is at the rate of 9.5 of water per pound of coal, $\frac{1}{8}$ lb. $-$ $\frac{1}{9.5}$ lb. of coal is saved for each pound of water evaporated and the saving amounts to

$$\left\{\frac{\frac{1}{8} - \frac{1}{9.5}}{\frac{1}{8}}\right\} \times 100 = 15.78 \text{ per cent.}$$

Size of Safety Valve for Compressed-Air Tank—What size of pop safety valve should be used for a compressed-air tank supplied from a compressor having a rated maximum capacity of 130 cu.ft. of free air per min. compressed to 100 lb. per sq.in. gage pressure?

P. E. C.

The safety-valve capacity should be 25 per cent. in excess of the rated maximum capacity of the compressor, or

130 + 25 per cent. of 130 = 162.5 cu.ft. per min.

and the size of valve required may be determined from the formula,

$$Q = 28\ PDl, \text{ or } D = \frac{Q}{28\ P\ l}$$

in which

Q = Discharging capacity of the valve in cubic feet of free air per minute = 162.5 cu.ft.;

D = Size of valve in inches;

P = Absolute pressure of air relieved by the valve = 100 + 14.7 or 114.7;

l = Lift of valve, which for standard pop valves may be taken as $\frac{1}{31}$ of D.

By substituting in the formula and solving for D,

$$D = \frac{162.5}{28 \times 114.7 \times \frac{1}{31} D} = 1.25$$

that is, a $1\tfrac{1}{4}$-in. safety valve should be used.

The Electric Traction Elevator*

Elevators may be classified first according to the driving power employed, which gives three principal classes, namely, steam-driven, hydraulic and electric elevators.

The first class is now practically obsolete. There are, of course, a few of them still running, but there are no new installations.

Hydraulic elevators may be divided into several groups, depending upon the method in which the hydraulic power is applied. Some of these types are: The horizontal, rope geared; the vertical, rope geared; and the plunger, which is direct connected. The plunger type practically superseded other types of hydraulic elevators during the period of 1904 to 1907, but has itself been almost entirely superseded by the 1 to 1 gearless electric-traction type.

Without considering in detail the technical features of the plunger elevator, the principal reasons for this change may be summarized in its comparison with the gearless traction type as follows:

1. Higher initial cost of plunger installation.
2. Larger amount of total space in the building occupied by the machinery.
3. Lower car mileage and consequently more elevators required for the same service.
4. Higher power consumption.

As to the location of the electric elevator, this is preferably directly over the hatchway, an arrangement which gives the best traction, least amount of ropes, minimum space required, longer rope life and higher efficiency.

The roping is extremely simple, usually six ropes of ⅝-in. diameter being used. The material is soft steel and in actual installations there is generally a safety factor of not less than 12. Each rope is provided with a self-adjusting rope hitch of the ball-and-socket type, which, owing to gradual creeping, prevents any excessive twisting stress and relieves the usual bending stresses at the hitch, caused by vibration.

A traction machine is arranged so that in case of overrun at the terminals either the car or the counterweight strikes an oil buffer, thereby reducing the traction sufficiently to prevent further motion of the car, even if the motor keeps on running. The car buffer is of the spring-return type and is mounted in the bottom of the pit.

The counterweight equals the weight of the car and usually about 40 per cent. of the maximum load. If we consider an elevator of 2500 lb. lifting capacity, 40 per cent. of this equals 1000 lb. (the overbalance) and this represents about six or seven persons. With such a condition of loading it is apparent that there is no net load to be lifted and, therefore, the only power required is for acceleration and to overcome friction and electrical losses.

ROPE COMPENSATION

It is obvious that with a high-rise elevator the variation in the net load on the elevator machine due to the shifting of the weight of the hoisting ropes from one side to the other as the car moves up and down would be excessive if this was not compensated for. This compensation is usually obtained by means of chains or ropes attached to the car and counterweight and running down the hatch in a loop. The weight per foot of these compensating ropes is such that, together with the electric cables that lead to the car, they compensate fully the weight of the hoisting ropes for all positions of the car.

For all high-speed, high-rise elevators compensating ropes are used and in the pit a tension device is provided for the compensating ropes. For moderate rises and comparatively low speeds, chains are used instead of ropes.

DRIVING MOTOR

The motor is of the slow-speed type, generally having six poles and provided with a shunt field only. The armature is series wound with conductors of rectangular cross-section in order to get in the maximum amount of copper. With a 36-in. driving sheave, a car speed of 600 ft. per min. corresponds to 63.5 r.p.m. of the motor armature.

For a considerable time it was considered that such a slow-speed motor delivering around 35 hp. would have an exceedingly low efficiency, but this is not the case. On the contrary, it has been demonstrated that a motor with this low speed can be designed to have just as high efficiencies as any high-speed motor.

Passing now to the different parts of the hoisting engine, the driving sheave is mostly 36 in. diameter, is cast integral with the brake wheel, and is bolted to the armature sleeve or spider. Circular rope grooves are employed. The magnet brake is of the shoe type, usually provided with a series winding for quick release and a shunt winding for holding. The brake shoes are lined with fabricated asbestos. The gradual and soft application of the brake is obtained by magnetic retardation of the magnet cores. The brake shoes used to be lined with leather, but after exhaustive tests of a number of different braking materials it was found that a certain kind of fabricated asbestos was the most suitable, its particular characteristics being that the friction between the lining and the brake wheel is constant at all times.

Elevators of the gearless traction type have been for some time equipped with ball or roller bearings. These are used for both the main motor and the rope sheaves. This was done primarily to gain space, because it is readily apparent that these anti-friction bearings take up much less room than the plain solid bearings. Personally I consider ball bearings superior to roller bearings for elevator machines. With roller bearings slightly out of alignment, even though this be insufficient to set up destructive strains, the friction will be increased materially. As a matter of fact, actual tests have shown that friction induced in this manner can readily be in excess of the friction in a plain bearing. Ball bearings are capable of resisting a certain amount of end thrust, which in the case of these traction machines is sufficient to take care of the "float" of the armature, caused partly from magnetic action and partly by the action of the hoisting ropes. Roller bearings will permit of no end thrust at all, and therefore, when they are used additional means must be provided to take care of this.

It is necessary, of course, to provide some lubrication in a ball bearing so as to prevent cutting, particularly of the cage; therefore, grease is provided, which will stay in the bearing. Furthermore, grease is most efficient in ball bearings for elevator machinery to prevent corrosion of the balls and races. A little rusty speck on either the race or a ball will soon destroy the bearing; hence these bearings must be usually well protected. If the grease is wiped out and the bearings run perfectly dry, the apparent friction losses will have been reduced to about one-fifth of that with lubrication.

SPEED CONTROL

Speed variation is obtained partly by field regulation and partly by series and bypass resistance in the armature circuit. The field regulation is usually capable of reducing the speed down to 60 or 40 per cent. of full speed, and further reduction is obtained by resistance control, as previously mentioned.

The combination of both methods is necessary to obtain sufficiently slow speed—about 60 ft. per min. This slow-speed car is required to make accurate stops both at intermediate and terminal landings and also in order to be able to make a very short travel or to "inch up or down to the landing."

In connection with the regular operating features of the control apparatus, there are also a number of other features introduced for safety. Some of these are:

1. Automatic return of car switch to off position.
2. Automatic stopping switch on car for stopping at terminal landings.
3. Final cutout limit switches in hatchway, operating independently of the automatic stopping switch.
4. Automatic stopping of elevator in case of over-speed by means of an electric contact operated by a centrifugal governor which will apply the electromechanical-brake and dynamo-brake effect on the armature, and, finally, the electric safety on the car.
5. Oil buffers, as previously mentioned, are capable of independently stopping the fully loaded car when descending at 50 per cent. excess speed without discomfort to the passengers.
6. Regulation of the shunt field by centrifugal governor to maintain constant full speed with variable loads.
7. For high-rise elevators the use of a retarding and latching device.

LOADS AND SPEEDS

Gearless traction machines utilizing 1 to 1 or 2 to 1 roping have been built for loads varying from 2000 lb. up to 11,000 lb. at car speeds from 350 to 700 ft. per min. Of these duties the most generally used for the modern high office building, utilizing 1 to 1 roping, is about 2500 lb. at 600 or 700 ft. per min., although in many instances a load of 2500 lb. at 500 or 550 ft. per min. is suitable. The high rise elevators in the Woolworth Building run at a speed of 700 ft. per min. In the new Equitable Building certain of the elevators are arranged to run a portion of their travel on express service at a speed of 650 ft. per min., and the remainder of their travel on local service at 550 ft. per min. The change in car speed is automatically accomplished at the point where the service changes.

*Excerpts from an address of David Linquist, chief engineer of the Otis Elevator Co., before the New York Section of the American Society of Mechanical Engineers.

For more moderate speeds and also for the heavier loads 2 to 1 roping is utilized, which retains the same safety features and general characteristics as in the 1 to 1.

The traction principle is also applicable to elevator machines employing moderately high-speed motors with some form of gearing between the motor and the driving sheave. This type of machine is most suitable where lighter capacities are involved or where the service conditions are not so severe. Under these conditions the power consumed will be comparatively light on account of the small mileage, and hence the more expensive gearless machine with its reduced power consumption may not be necessary.

Two types of geared machines have been developed—one employing worm gear and the other herring-bone gear reduction. Of these the worm gear is suitable for the slow or more moderate speeds and is extensively used for this purpose. The machine with herring-bone gear reduction is not suitable for slow car speeds on account of the difficulty in obtaining sufficient speed reduction. It is undoubtedly more efficient than worm gearing, and it has been used with some success in connection with quite high-speed elevators. The fact that the herring-bone gear has been used for these high speeds does not mean that it is to be considered equal to the gearless machine, with which it cannot compare as to operating features and power consumption. The worm gear has inherently the least tendency to vibrate, but the herring-bone gear is generally more efficient.

The maximum efficiency of the high-speed motor used in connection with the geared machine may be practically as high as that of the gearless, but the efficiency at lighter loads, which is the most prevalent running condition, is lower; hence, the high-speed motor is at a disadvantage. Equal amounts of field regulation may be applied to both types.

For high speeds it may be taken that under the best conditions the gearing has a loss of about 10 per cent.

ELECTRO-MECHANICAL SAFETY DEVICES

1. The safety should be so arranged that the application of a predetermined but definite light retarding force will stop the car and net load without shock in case the hoisting ropes are intact.

2. The safety device should be so arranged that the application of a predetermined definite strong retarding force will gradually bring the car and maximum load to rest in the case of a free falling car.

3. The light retarding force should be immediately applied, preferably by means of a centrifugal governor, in case the car should attain excessive speed in either direction.

4. It should be possible to immediately apply the light retarding force from within the car when desired.

5. The light retarding force should be applied automatically in case of overrun at the upper or lower terminals, and be arranged not to interfere with the starting of the car in the opposite direction.

6. The strong retarding force should start to apply the instant the hoist ropes part, independent of the speed of the car and counterweight. In safe lifts a strong retarding force should be automatically applied independent of the parting of the hoisting ropes at a definite speed which should be higher than the speed at which the light retarding force is applied.

7. A tripping governor should not be necessary to apply the strong retarding force.

8. The releasing carrier, even though improperly adjusted, should not prevent the application of a strong retarding force to the car in case the ropes parted.

9. The principal actuating parts of the safety should be made to move automatically at frequent intervals, in order to prevent them from clogging up or corroding together. This motion of the actuating parts need only be very small to give the desired results, but some motion is necessary to secure dependable action of the safety.

The light retarding force is obtained by one helical steel spring forcing the curved wedges between the rollers of the safety jaw. When the car is in service this spring is held under compression by means of an electromagnet.

DISCUSSION

Some questions were asked with reference to the rope strains. In reply Mr. Linquist stated that under ordinary conditions the apparent safety factor with the load at rest was never less than 12. This did not take into account the additional stress due to acceleration and bending of the rope, which would make the real safety factor hardly over 8.

As to whether anything had been done with reference to the employment of alternating current in electric elevator service, the speaker replied that, up to the present time no alternating-current elevators have been put on the market of the direct-connected or gearless traction type. Those in use are of the geared type, for speeds up to 350 ft. per min. approximately. For 250 to 300 ft., two motors are employed, with a speed variation of from 1 to 3 down to 1 to 4; in other words, the reduction of speed is to ⅓ or ¼. The change in speed is obtained by rearranging the connections of the motor in such way as to change from a small number of poles giving the high speed to a large number of poles giving the slow speed.

With reference to the smooth application of the brake, no known method has been used for magnetically retarding an alternating-current brake. There dashpot retardation has to be employed, and in the majority of cases the brake-magnet parts are inclosed in coil-type casings and the brake-magnet cores are formed partly for plungers to act as dashpots.

Going back to the question whether anything has been attempted in the line of gearless alternating-current traction machines, Mr. Linquist stated that last year he had built such a machine. Half of the outfit consisted of an alternating-current motor, and at the same time it acted as a motor it also acted as a converter. The other half of the machine consisted practically of a direct-current motor with a revolving field with unusually large speed variation and speed regulation. The machine was built and tested, and so far as the speed control was concerned it was perfect. There was field regulation from no speed up to full speed, and it was possible to obtain any desired speed without resorting to resistance control. On the other hand, the losses were comparatively high and the efficiency was not very good. As far as operation was concerned it was successful, but considering the cost of operation and first cost, it was hardly a commercial proposition, because as good results and perhaps better could be obtained by changing the alternating current by means of converters or motor-generator sets into direct current and operating direct-current elevators.

Electric Ship Propulsion

Before a joint meeting of the Western Society of Engineers and the American Institute of Electrical Engineers, W. L. R. Emmet, of the General Electric Co., gave an interesting talk on the above subject on the evening of Apr. 26. The development of the high-speed turbine paved the way for electric ship propulsion. Its application in this field had been long foreseen. Mr. Curtis had worked for two or three years on the problem, and since 1900 Mr. Emmet had spent much of his time on the turbine. About six years ago he had first approached the Navy with a view to equipping battleships for electric drive, but at about the same time the question of reduction gearing had been brought to the front and the Navy had been impressed to the extent that the collier "Neptune" was equipped with turbines and reducing gears. The excellent results obtained aroused interest in the general question of reducing the speed between the turbine and the propeller, and as a result Mr. Emmet secured the contract to equip the "Jupiter" electrically. During the two years this ship has been in service it has made a wonderful record. Results 20 per cent. better than from any ship afloat have been obtained, and the equipment is as good as new. The turbines run regularly on a water rate of 11 lb. per shaft hp.-hr., which may be compared to 14 lb., the best obtainable from a triple-expansion-engine-driven vessel. Naturally, electric propulsion gained in favor, and about a year ago it began to be thought of seriously for battleships. As the advantages of the electric drive increase with the power required, Mr. Emmet had been particularly anxious to equip a battleship, and only within the last few days the contract for the "California" had been closed. An estimate on the cost of installing electric drive showed that a saving of $160,000 would be effected over the cost of the turbine equipment that had been previously planned. In these large powers all sorts of complications arise when the turbines drive the propellers directly or through reduction gearing. With the latter the power must be divided up between a large number of units, as there is a limit to the size and capacity of individual gears beyond which it would not be safe to pass. In ships where the turbines drive the propellers directly there must be a compromise in speed. The turns made by the propellers are much too high, and the turbine runs at about a tenth of the speed it ought to have to give the best results. Besides, there is great complication of piping for high- and low-pressure turbines, and as the pressure in some of this piping is below the atmosphere, air leaks are liable to develop and lower the efficiency by reducing the vacuum. On the other hand, with the modern electric drive the loss cannot exceed 8 per cent. The apparatus is designed so that practically a constant water rate is maintained for all loads.

In the "Lusitania," with a speed of 180 r.p.m. the propeller efficiency is 62 per cent. The turbines for the "California" will have a speed of 2200 r.p.m. and deliver to the generator 75 per cent. of the available energy in the steam. In the latter the turbines will be simple, compact machines, while those of the "Lusitania" are enormous. By dropping the propeller speed of the "Pennsylvania" from 222 to 160 r.p.m., the efficiency would be increased 8 per cent., which would just counterbalance the loss by electric propulsion. Comparing the present equipment with an electrically propelled "Pennsylvania," the efficiencies would bear a ratio of about 63 to 73 per cent.

Investigating the possibilities of reduction gearing held back electric propulsion. Parsons had condemned the latter and favored gears. Reduction gearing has proven successful on small ships running at moderate speeds. As the speed of the vessel increases, however, the ratio of reduction between turbine and propeller speeds becomes greater and the gear problem is more difficult. The General Electric Co. had become interested in gearing and developed a system which was installed on three freighters equipped with turbines. These gears may be applied to cases where electric propulsion is barred, but in the favorable cases the speaker could not imagine any arrangement of gears which would be anywhere near as good as electric drive.

Electric propulsion is to have a wide field of application. The company had recently figured on two large Russian cruisers and on a number for our own navy. Mr. Emmet stated that he could reëquip the "Lusitania" and save $150,000 per year in the cost of coal. Electric drive for liners so far exceeds engines that the equipment would pay for itself in one or two years.

Slides were thrown on the screen showing the 20,000-ton collier "Jupiter" and its power-plant equipment. At 15 knots the vessel requires 7000 hp. The generator is of simple and rugged construction and is not restricted as to voltage or frequency. It has a capacity very little greater than required by the motors, so that even a short circuit would not result in much injury. The motors are of the three-phase induction type, the stator having bar windings and the rotor a definite wound design provided with external resistance to be used when reversing. The governor is designed much like a tachometer with a system of fulcrums which can be moved in and out and varied through a wide range of speed.

For the "California" each turbine will have a maximum capacity of 18,000 shaft horsepower and on maximum load will require 170,000 lb. of steam per hour. The vessel has a displacement of 30,000 tons and a maximum speed of 22 knots, and yet each of the two turbines driving it is only 14 ft. long. The motors are 12 ft. in diameter by 11 ft. wide. Consequently, the entire equipment occupies comparatively little space, and the first impression would be that it was designed for a tugboat or at least a vessel much smaller than the "California." Even the auxiliaries will be electric driven, and the only steam piping entering the engine room will be the two leads for the main turbines.

The two turbines will develop a maximum of 36,000 hp., which is required to force the vessel to 22 knots. At 14 knots 7000 hp. is required. Performance charts showed that the water rates will remain practically constant over a wide range of speed. At 14 and 21 knots it was 10¾ lb. per shaft hp.-hr., and for the range in speed between these two points it remained between 10 and 11 lb. At a speed of 15 knots, 28½ in. of vacuum, no superheat and 190-lb. gage pressure, the "Jupiter" showed a performance of 11 lb. per shaft hp.-hr. These figures are exceptional and can be obtained only when both the turbine and the propeller are running at their most efficient speeds. By diminishing the excitation with the speed the efficiency is maintained and at the same time the torque is not reduced beyond that which is required. It is simply a case of diminishing the excitation until the propellers are turned at the right speed with the minimum amount of steam. One of the big problems is reversing, but it has been met by using high excitation while the change in direction is taking place.

With the reduction gear the great problem has been to equally distribute the load over the entire face of the gear. With a rigid gear most of the load is applied near the ends of the teeth. In the General Electric design this difficulty has been overcome by a gear made up of separate disks which will give sidewise and distribute the load over the surface.

A number of charts comparing the relative economy of engine-driven vessels, geared turbines and electric propulsion showed the following water rates per shaft horsepower-hour. For the "Vespasian," with triple-expansion engines, the water rate was 19 lb.; with geared turbines, 16 lb.; and with electric drive, 12.7 lb. The "Cairngowan," with triple-expansion engines, developed a shaft horsepower-hour on 17.3 lb. of steam, and the "Cairnross," a sister ship with geared turbines, on 14 lb. It was estimated that either vessel equipped with electric drive would develop a shaft horsepower-hour on 11.77 lb. of steam. The above figures tend to prove the assertion made by Mr. Emmet that electric drive over triple-expansion engines will reduce the water rate about one-third.

In the discussion it was brought out that as induction motors cannot run above synchronous speed, the propellers cannot race. Even in a heavy sea, with the propellers entirely out of water there is no vibration or any indication of a change in speed. As to the proper fields for reduction gearing and electric drive, Mr. Emmet made the general statement that in all ships requiring above 15,000 to 20,000 hp., gearing would make a poor comparison. In vessels requiring 10,000 hp. and less and running at a low speed, reduction gearing would perhaps make the best showing. The field for electric drive is in large merchant ships and all battleships with the exception of torpedo boats and destroyers, where restrictions in weight prohibit its use.

Recent Court Decisions

Digested by A. L. H. STREET

Duty to Guard Ash Piles—When the owner of a power plant has knowingly permitted children to play about a pile upon which hot ashes from the boilers are deposited, he is under a legal duty to either maintain a guard or give suitable warning to prevent injury to such children, according to a decision of the United States Circuit Court of Appeals, for the Sixth Circuit, in the case of O'Donnell vs. Escanaba Manufacturing Co., 212 "Federal Reporter," 648. In this case judgment was affirmed in favor of a ten-year old girl who was burned in undertaking to walk over a pile of hot ashes.

A Mandatory Statute—A law enacted by the Oregon Legislature in 1911, to promote the safety of electricians, requires dangerous wires to be completely insulated, prohibits intermingling of dead and live wires, requires the supports of live wires to be so designated that the presence of such wires shall be instantly apparent, and requires such wires to be so strung as not to endanger repairmen working near them, etc. Applying this law to an action for the death of a lineman who was electrocuted while working on a pole which supported uninsulated wires, the Oregon Supreme Court lately decided, in the case of McClaugherty vs. Rogue River Electric Co., 140 "Pacific Reporter," 64, that an employing electric company cannot excuse liability for failing to comply with such statutory requirements, by installing switches in such a location that electric current can be shut off while work is being done. The court says: "The requirements of the statute as to the safeguards enumerated are positive and mandatory. There are no alternatives."

Right to Enjoin Construction of Dam—That suit does not lie to enjoin the construction of a power dam when it is being erected under legislative authority is the gist of the decision of the North Carolina Supreme Court in the case of Tucker & Carter Rope Co. vs. Southern Aluminum Co., 81 "Southeastern Reporter," 771. The court said: "The defendant's dam is being constructed under express legislative authority, and is a lawful structure per se, and cannot be restrained as a public or private nuisance. If, in the course of its lawful operation, it may inflict injury upon the plaintiff, it is amply able to respond in damages. Whether the relief to which the plaintiff shall be entitled will be the recovery of damages or the abatement of the height of the dam is a matter which will arise when the facts are found; but certainly the courts will not stop the construction of the dam more than 18 months before its completion upon the allegation of the plaintiff, which is denied in the answer, that it will injure its property if built to the height that is proposed."

Effect of Washington Public Service Commission Law—As construed by the Washington Supreme Court in the recent case of Tacoma Railway & Power Co. vs. City of Tacoma, 140 "Pacific Reporter," 565, the Public Service Commission law of that state "deals only with the questions of safety, efficiency, rates and equality of public service. The power to grant a limited franchise is still in the city. No power was given to the public-service commission to grant, modify, or abrogate franchises or contracts arising out of franchises, except in regard to rates and the regulation of service in respect to its safety, efficiency and equality. It was not the purpose of the act to enlarge franchises, or to require the performance of acts being exercised under a franchise which could not be legally exercised, or for a longer period than such acts could be legally exercised." Hence, it is found that the law did not abrogate a condition in an electric franchise previously granted by the City of Tacoma to an electric company, providing that it should not furnish electricity for lighting purposes.

Cause of Turbine Failure

The "Journal of Electricity, Power and Gas" of Apr. 17 contains the finding of the board which investigated the recent turbine failures at the Fruitville plant of the Southern Pacific Co.

It appears that the trouble began by one of the turbines losing six blades of the impulse element. The load was shifted to the other turbine, but on the following day practically all the intermediate blading of the second machine let go. The first machine being open and under repair at this time, the service was crippled for several hours. Investigation showed the cause of the blade failure in the second machine to have been the rusting of the metal in which the blades are secured. This permitted some of the blades to come out and in turn rip out others, until the entire intermediate stage had been destroyed. It is believed that the rusting resulted from leakage of steam past the throttle when the machine was stationary. It is very difficult to keep the throttles absolutely tight, but arrangements have been made so that in the future this leakage will exhaust to the atmosphere instead of into the turbine casing. Moreover, rusting will be prevented by the introduction of brass lining strips, which the makers are now recommending with this type of turbine.

Ice Plants Not Immune from Accidents

The fact that the refrigerating industry in which chemicals and highly compressed gases are used in connection with tanks, piping and moving machinery is not immune from accidents is attracting the attention of municipal authorities to such an extent that regulations for installing and operating the plants have been drawn up and put into effect in many localities. No doubt, these regulations will have to be revised as experience is gained in their application, and in this respect they may be expected to have a history similar to that of analogous regulations applying to steam boilers. As in almost every other industry, the majority of the accidents that occur are avoidable, provided sound engineering principles are followed in the design, installation and operation of the plants. It follows, then, that the engineer who designs the plant and the man who supervises the installation should bear in mind the question of safety, and it is equally important to place competent men in charge of the operation of the plants, because the judgment and ability of the men are exceedingly important factors in preventing accidents.—"Travelers Standard."

Testing a Refrigerating System with Air

It is customary to test a refrigerating system with air pressure before charging with ammonia. This should be carefully done by experienced men to avoid an explosion by the ignition of the vapor from the lubricating oil, caused by the heat of compression.

A thin coating of lard oil should first be applied by hand to the walls of the compressor cylinders and the compressor allowed to run until the pressure reaches 100 lb. or more. It should then be stopped long enough to cool down, then started up again and operated until forty or fifty pounds of additional pressure is obtained, then stopped again. When sufficiently cooled it should once more be started, but at reduced speed, and stopped whenever the discharge pipe becomes hot enough to be uncomfortable to the hand. If these precautions are taken there is little chance of an explosion from internal causes during the test. The men should be kept away from the apparatus as much as possible, however, as there is always a possibility that an accident may occur through the failure of an imperfect joint or from unforeseen weakness in some other part.

Some Precautions Ice-Plant Engineers Should Observe

The operating engineer of a refrigerating plant should remember that he is subject to many of the hazards that are to be found in the ordinary power plant and also to some additional ones. For example, in compressing air he should never use a machine that has recently been used to compress ammonia, and in opening gage-cocks he should stand at the side rather than in front of the gage-glasses. Such precautions as standing at the side rather than in front of cylinders or compressors and refraining from calking pipes or tightening up fittings while they are under pressure are generally understood, but often disregarded. It is particularly dangerous to calk joints or tighten nuts or fittings under pressure. Many fatal accidents have been caused in this way.

However carefully a system is designed and installed, a certain amount of liquid is likely to accumulate, and its presence in the compressor is always a source of danger. The obvious remedy is to provide a properly located relief valve of sufficient capacity to permit the discharge of practically all the liquid present before the piston reaches the end of its stroke. There are cases where considerable difficulty may be experienced in equipping compressors with such devices, but the greater safety gained is well worth the trouble.

Every steam engine should be provided with a safety stop wholly independent of the ordinary governor. In case the governor fails to work properly and the engine starts to "race," the independent safety stop is supposed to operate as soon as the speed exceeds a predetermined limit, shutting off the steam, bringing the engine to a standstill, and preventing the bursting of the flywheel and other serious consequences.

Piston rings formerly caused considerable trouble, but ordinary snap rings are now used with satisfactory results, so far as accidents from this cause are concerned.—"Travelers Standard."

Ice-Making Plants in the United States

There are in the United States over 12,500 ice-making plants, having an aggregate annual output of about twenty million tons. This does not include the thousands of private refrigerating plants in small restaurants, meat markets, grocery stores and private dwellings. The principles of artificial refrigeration are being applied in more than 150 different industries, including among others mining, paper making, woolen and silk manufacturing, laundering, and tobacco manufacturing.

OBITUARY

JOSEPH G. GANNON

Joseph Charles Gannon, chief engineer of the Greenpoint Hospital, Brooklyn, N. Y., died Apr. 17 from pneumonia. He was 47 years of age and had long been a member of the National Association of Stationary Engineers.

ANDREW J. WILSON

Andrew Joseph Wilson, manager of the Lynn Canadian Refrigeration Co., and a consulting engineer, died Apr. 18, from heart failure. He was 39 years of age and had spent twenty years in Toronto, Can., where his death took place.

PERSONALS

John Sabin, who likes to recall that he is the man who sold the first Bundy trap something more than a quarter of a century ago, has been appointed general manager of the Nashua Machine Co., the manufacturer of the trap

ENGINEERING AFFAIRS

The American Boiler Manufacturers' Association will hold its 1915 convention at the Lawrence Hotel, Erie, Penn., on June 21, 22 and 23. Among other matters the convention will consider the standardization of a uniform cost system and of material, workmanship and terms of payment clauses in specifications. The committee on the A. S. M. E. Boiler Code will report and ways and means will be discussed for securing the adoption of the code in the several states. The attendance of all boiler manufacturers in the United States and Canada is requested. Those expecting to be present should notify the secretary, J. D. Farasey, East 37th St. and Erie Railroad, Cleveland, Ohio.

The National District Heating Association will hold its seventh annual convention on June 1, 2 and 3 at the Hotel Sherman, Chicago. The following papers will be presented: "Commercial End of the Heating Business," by C. F. Oehlman.

Denver Gas & Electric Co.; "Operating Experience with Bleeder Type Turbines," by F. W. Laas, chief engineer, Iowa Railway & Light Co., Cedar Rapids, Iowa; "The Hot Water Heating System at the Grand Central Terminal," by W. G. Carlton, New York City; "A Pressure Study of a Steam Distribution System," by C. C. Wilcox, engineer, Hodenpyl Hardy Co., Jackson, Mich.; and "Exhaust Steam vs. Live Steam for Heating," by George W. Martin, New York Service Co., New York City.

NEW PUBLICATIONS

ELEMENTARY ELECTRICITY AND MAGNETISM. By W. S. Franklin and Barry MacNutt. Published by the MacMillan Co., New York, 1914. Size, 4½x7½ in; 174 pages; illustrated. Price, $1.25 net.

A simple and well-illustrated presentation of the principles of electricity, studied from its effects rather than from the theoretical standpoint. The pump analogy is used to advantage in describing electromotive force and resistance. While the book is intended primarily for the student, its usefulness to the practical man might have been enhanced had more of the illustrations been selected from modern commercial apparatus.

HEAT ENGINEERING. By Arthur M. Greene, Jr., Professor of Mechanical Engineering, Rensselaer Polytechnic Institute. Published by the McGraw-Hill Book Co., Inc., New York. Cloth; 462 pages; 6x9 in.; 198 illustrations. Price, $4.

This volume is announced as a textbook of applied thermodynamics for engineers and technical students. The first chapter contains a brief review of the theory of thermodynamics. Chapters follow on heat transmission, air compressors, the steam engine, the steam turbine, condensing apparatus, internal-combustion engines and refrigeration. Each chapter is concluded by a series of topics and problems. The topics consist of a series of questions relating to the text and the problems (without answers) illustrate its use. The book is decidedly unusual in its treatment of the steam boiler. The combustion of fuel in boilers is briefly described in the section relating to internal-combustion engines, but otherwise a consideration of the steam boiler, its theory, design and performance, is missing. As half of the book applies to apparatus using steam, the omission seems unexplainable. With this exception the book appears to present a useful outline of applied thermodynamics.

ENGINEERING ECONOMICS. By John C. L. Fish, Professor of Railroad Engineering, Leland Stanford, Jr., University. Published by the McGraw-Hill Book Co., Inc., New York. Cloth; 217 pages; 6x9 in. Price, $2.

The title of a book is sometimes descriptive of its contents. Professor Fish's treatise, in spite of its title, does not attempt to set forth laws of wealth peculiar to engineering, but it does explain the factors on which depend the long-run least cost of engineering structures. The book deals mainly with the economic selection of the means of accomplishing engineering ends, and this selection is defined as the choice based on the long-run least cost. The opening chapters are devoted to the derivation of formulas for calculating simple and compound interest and to an explanation of sinking funds, capitalized value and other relevant financial terms. The essential components of first cost, such as investigation, promotion and construction expenses, are next outlined; and scrap value, depreciation and amortization are defined. The application of these terms is shown in a chapter on the elements of yearly cost of service. The method of figuring amortization and interest charges is clearly and completely handled, but the attention paid to operation and maintenance expenses seems inadequately brief. No doubt, the author emphasized the financial and accounting problems, believing that the engineer needed no information on material and labor expenditures. The elements described are illustrated by fifteen numerical examples, four of which apply to the power plant. A useful feature is the list of depreciation rates accepted by various legal authorities, in which apear a number of items of power-plant equipment. There are also a number of references to published cost data and to estimating methods used in designing engineering structures. While the book seems to have been written chiefly for the designing, it should prove useful to any engineer requiring a working knowledge of the principles underlying cost-of-operation calculations.

ENGINEERING EXPERIMENT STATION BULLETIN

Volume 10 of the "Bulletins of the Engineering Experiment Station," University of Illinois, has recently come from the press, bound in half-leather and containing reports of the work at the experiment station from September, 1913, to April, 1914. The subjects covered are: The Strength of I-beams in Flexure, by H. F. Moore; Coal Washing in Illinois, by F. C. Lincoln; The Mortar-Making Qualities of Illinois Sands, by C. C. Wiley; Tests of Bond between Concrete and Steel, by D. A. Abrams; Magnetic and Other Properties of Electrolytic Iron Melted in Vacuo, by T. D. Yensen; Acoustics of Auditoriums, by F. R. Watson; and the Tractive Resistance of a 28-Ton Electric Car, by H. H. Dunn.

BUSINESS ITEMS

The M. W. Kellogg Co., New York, has moved its offices into larger quarters at 90 West St.

E. G. Calles Co., Chicago, Ill., has been appointed agent for the S-C Regulator Co., Fostoria, Ohio, for the Chicago territory.

The McClave-Brooks Co., Scranton, Penn., has opened a Boston office in the Equitable Building, No. 202, in charge of S. C. Smith, manager.

The Pittsburgh branch office of the Bristol Co., Waterbury, Conn., has been moved from 1670 Frick Annex into better quarters at 832 Frick Building. R. B. Anthony is district manager.

The Wilson-Snyder Manufacturing Co. and the Wilson-Snyder Centrifugal Pump Co., of Pittsburgh, Penn., have opened a branch office at 52 Vanderbilt Ave., New York City, in charge of A. H. Sherwood.

The general sales department of the Nashua Machine Co. will hereafter be located in the principal office of the company, in Nashua, N. H. A Boston office will be maintained for New England business, in charge of E. M. Stevens, who has been associated with the business for many years.

M. N. MacLaren, New York manager of the Nordberg Manufacturing Co., of Milwaukee, Wis., builder of Corliss engines, uniflow engines, poppet-valve engines, high-compression oil engines, air compressors, hoisting engines, blowing engines, electric hoists, pumping engines, steam stamps, etc., announces the removal on Apr. 26 of the New York office from 42 Broadway to the new Equitable Building, 120 Broadway.

The C. W. Hunt Co., Inc., owing to increasing business, has moved its New York office from 45 Broadway, where it has been for 28 years, to the new building of the Adams Express Co., 61 Broadway. It will occupy a suite of offices on the 11th floor, which will give it much better facilities for transacting business. The company is a large manufacturer of coal-handling machinery, conveying machinery and small motor trucks.

The Wright Manufacturing Co. (alarm water columns, Emergency and Victor steam traps, Cyclone exhaust heads), the Austin Separator Co. (steam and oil separators), the Murray Specialty Mfg. Co. (Murray automatic boiler-feed regulators) have moved from 55-59 Woodbridge St., West, to larger and better quarters at 97-101 Woodbridge St., West, Detroit, Mich. The Murray Co. has just issued an attractive catalog, which can be had on application to the new address.

The Bruce-Macbeth Engine Co., Cleveland, Ohio, has recently made the following shipments: One 100-hp. natural-gas engine to the Fedders Manufacturing Co., Buffalo, N. Y.; one 350-hp. natural-gas engine and Steam Process to the Mansfield Milling Co., Mansfield, Ohio; one 150-hp. natural-gas engine to the Galion Iron Works & Manufacturing Co., Galion, Ohio; one 125-hp. natural-gas engine to the Setter Brothers Co., Cattaraugus, N. Y.; one 150-hp. natural-gas engine to the Dunn-Taft Co., Columbus, Ohio; one 150-hp. natural-gas engine to the Fostoria Glass Co., Moundsville, W. Va.; two 90-hp. natural-gas engines to the Brookville Glass & Tile Co., Brookville, Penn.

Kerr Turbine Co., Wellsville, N. Y., is distributing Bulletin No. 51, "Economy Geared Turbines," which explains the great advantages often obtained by interposing gears between turbine and driven generator, pump, blower or pulley, and also explains the new method by which Economy turbine gears are so accurately hobbed that no grinding or polishing is necessary for finish. A copy of this bulletin will be sent on request. Recent sales made by the Kerr Turbine Co. include the following: City of Atlantic City, N. J., 18,000,000-gal. Economy turbo-pump; City of Baltimore, 500-kw. Economy turbo-generator; City of Williamsport, Penn., 425 hp. turbine for driving a pump; City of Youngstown, Ohio, two 250-kw. turbo-alternators; dredge "Columbia," Port of Portland, Ore., two 1000-hp. geared turbines; Swift & Co., Chicago, 3 turbine units; Christian Moerlein Brewing Co., Cincinnati, 300-kw. turbo-generator; Carnegie Steel Co., Farrell, Penn., 125-hp. turbine; Jones & Laughlin Steel Co., Woodlawn, Penn., 325-hp. turbine; National Tube Co., Christy Park Works, McKeesport, Penn., 350-hp. turbine. Export orders include East Hull Gas Co., Groves, England; Corporation Gas Works, Birkenhead, England; and Armour de la Plata, Argentine.

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The Flow of Steam from one vessel to another through an orifice with parallel sides increases as the pressure difference increases, down to 58 per cent. of the absolute initial pressure. A greater pressure difference does not affect the velocity, even though discharging into a perfect vacuum. For example, steam at 100 lb. pressure will increase in velocity as the pressure against which it discharges diminishes down to 58 lb., then the velocity of the flow will remain constant no matter how much the receiver pressure may be reduced—even to a perfect vacuum. Therefore, steam at approximately 25⅓ lb. discharging into the atmosphere has attained the maximum velocity possible in such a nozzle, which is 1470 ft. per sec., because 58 per cent. of 25⅓ equals 14.7, or ordinary atmospheric pressure.

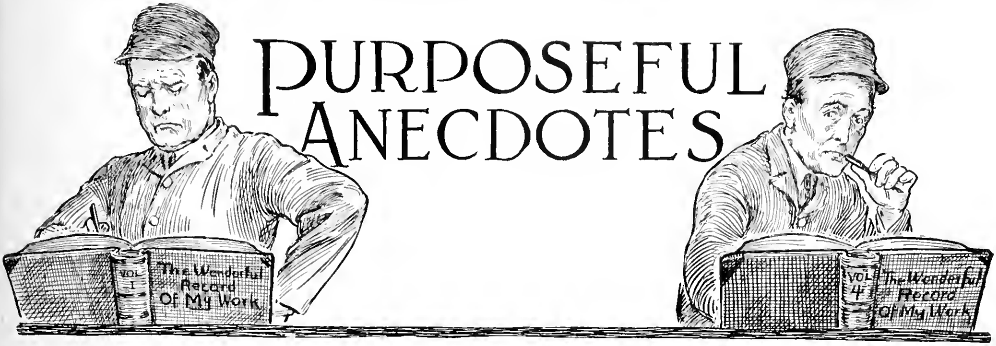
POWER GENERATION AND TRANSMISSION

POWER

ONE OF THE HILL ENGINEERING WEEKLIES

Vol. 41 NEW YORK, MAY 18, 1915 No. 20

PURPOSEFUL ANECDOTES



How I Earned My Raise

AFTER my first year in charge of our power plant I was told by the owner that my work was satisfactory—that I would be retained at the same salary.

The news, however, did not please me much. I had hoped for a raise. Why didn't I get it? Would I have to work another year at the same salary?

The more I thought about it, the more peevish I became, until I finally decided on a unique plan for throwing up my job. I would revenge myself by "heaping coals" of fire on the head of the owner. I would prove that I'm "game."

I began by working up a written "process system" that would enable my successor to pick up the plant where I left off, without difficulty.

I put down in black and white the peculiarities of our grates, boilers, draft, etc., and the method of firing that I believed to be best—

Position of ash doors, rate of feed of stokers, speed of fans, method of cutting out boilers, when to do it, method of cleaning, dangers—And other points that had given me trouble during my year in charge.

But I found that my grouch was beginning to leave. Writing about my plant made me THINK. I began to wonder if, after all, my methods were BEST. My interest increased. I studied. I experimented. And as a result, I learned that my old methods were NOT best, and I began putting BETTER methods in force.

I continued writing my process system, altering it wherever improvements in operation were made, and at the end of six months I had covered the entire plant. But I realized by this time that it was not yet at its best—that even better overall economy was possible and should be attained. I saw that we needed a little additional equipment and I could PROVE it with actual figures.

So, instead of resigning, as I first intended to do, I handed my process system to the owner, told him what I had done and what I had learned. I told him what was needed and why, and I won my point.

I did not have to wait the year out for my raise. TRY IT.

Boiler Plant of Union Brewery

By Thomas Wilson

SYNOPSIS—An isolated boiler plant of 1500-hp. rating equipped with complete coal- and ash-handling systems. Boilers have the new marine settings, and special precautions have been taken to insure a minimum loss of draft between the stack and furnace.

An uptodate boiler plant, unusually complete for its size and containing the latest features in boiler-room design, has recently been completed by the Otto F. Stifel Union Brewing Co., in St. Louis. The commercial life of the old boiler plant was rapidly drawing to a close, and the early intention of enlarging the brewery made the new plant imperative. As a starter only the boiler house was erected, across the street from the brewery. It is the intention to erect an engine room adjoining, but at present the old equipment, consisting of three engine-driven ammonia compressors and two generating units, is supplied with steam at 150 lb. pressure from the new boiler house. The pipe supplying steam for the above machines and for industrial uses in the brewery passes through a tunnel under the street. At the delivery end the supply is controlled by an electrically operated valve.

The new building is of fireproof construction throughout, as it is made up of brick walls, concrete floor, tile and concrete roof, steel sash and ventilators, and no wood except the doors. The interior dimensions are 47x64 ft., and the height from the floor to the roof trusses is 38 ft. It is equipped with three 500-hp. vertical water-tube boilers, and there is space for one more of the same size. The boilers, shown in Fig. 1, now carry a pressure of 150 lb. gage, but eventually will supply steam at 175 lb. pressure to the equipment of the new engine room. A feature of the boilers is the marine-type setting recently adopted in stationary work to reduce the radiation and eliminate infiltration of air. It is made up of 4½ in. of "circle" firebrick and 3 in. of asbestos fiber covered by steel plate. The exterior furnace walls, made up of 9 in. of firebrick and 12 in. of common brick, are protected by ¼-in. asbestos board and the steel-plate covering. This construction prevents leakage from the sides, and as the stoker works under a ledge it is easy to block off the air from the front.

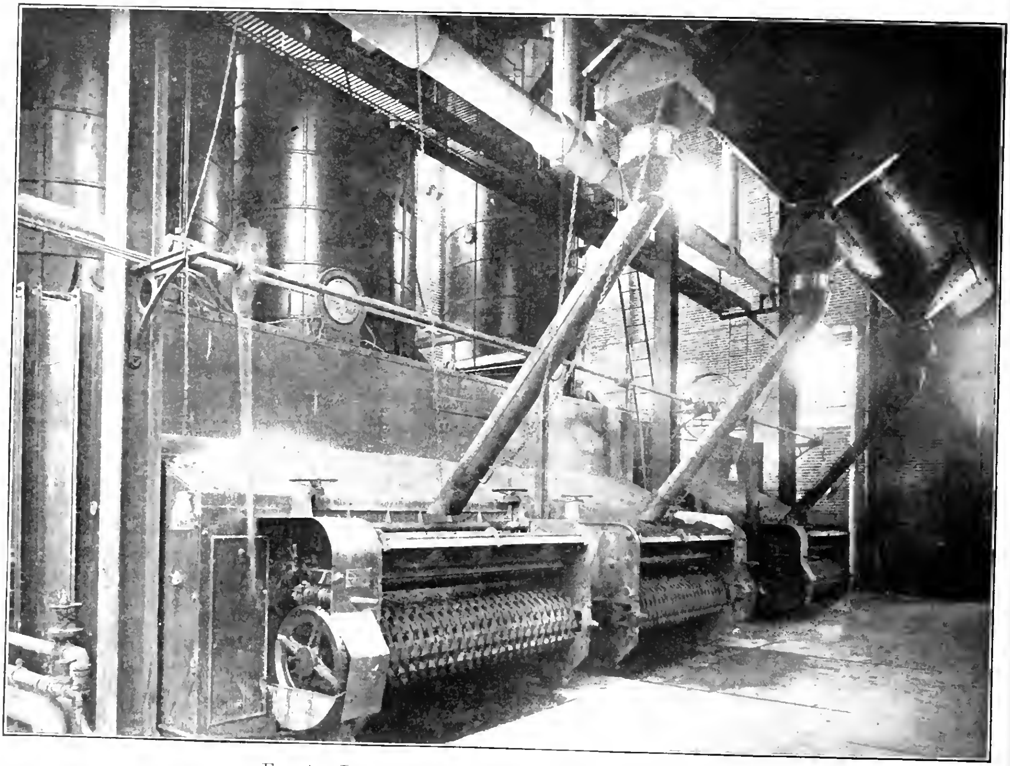


Fig. 1. Boiler House of the Union Brewing Co.

Stokers of the chain-grate type were installed, having an active width of 7 ft. 6 in., a length of 11 ft. 7 in. and an area of 87 sq.ft. To the 5000 sq.ft. of heating surface contained in each boiler, the above area bears a ratio of

1 to 57.5. This is somewhat higher than the usual 50 to 1, but in this particular case the grate surface was made less than the average for the following reasons: As fuel had to be carted eight blocks, it was decided in the interests of economy to use a high grade of Illinois

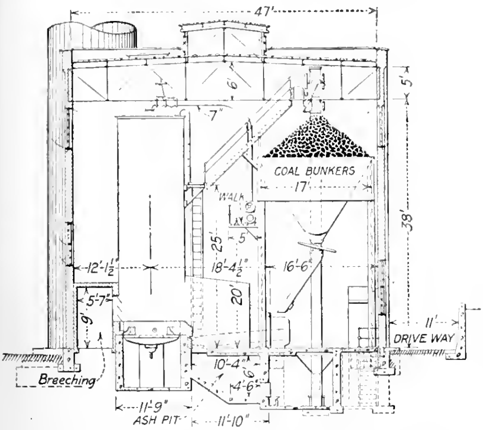


FIG. 2. TRANSVERSE SECTION OF BOILER PLANT

reduction of grate area was desirable and its installation an evidence of good engineering.

An inspection of the drawings will show that special precautions were taken to reduce to a minimum the loss of draft between the stack and the furnace. In the first place, under average conditions a boiler of the type installed shows a draft loss approximately only 0.2. This is from the boiler side of the damper to the entrance from the furnace. The low drop is partly due to the static effect of the hot gases rising in the first pass and dropping in the second pass after being cooled by coming in contact with the heating surface. Through three-wing dampers the gases discharge directly to a rectangular breeching built up from the floors and running straight to the stack. The breeching tapers toward the farthest boiler, but at the stack is 5 ft. 7 in. wide and 9 ft. high, giving an area of 50 sq.ft. in round numbers. It is made of tile, firebrick lined, and has a run of 57 ft.

The stack is one of the finest for its size in St. Louis. It rises 185 ft. above the boiler-room floor and has an internal diameter of 7 ft. 6 in. The shell is made of a special radial tile filled with reinforced concrete, and for a height of 70 ft. is lined with firebrick. An air space of 3 in., unfilled, separates the lining from the shell. For a gas temperature ranging around 500 deg. and allowing 100 lb. of gas per horsepower, the stack is figured to

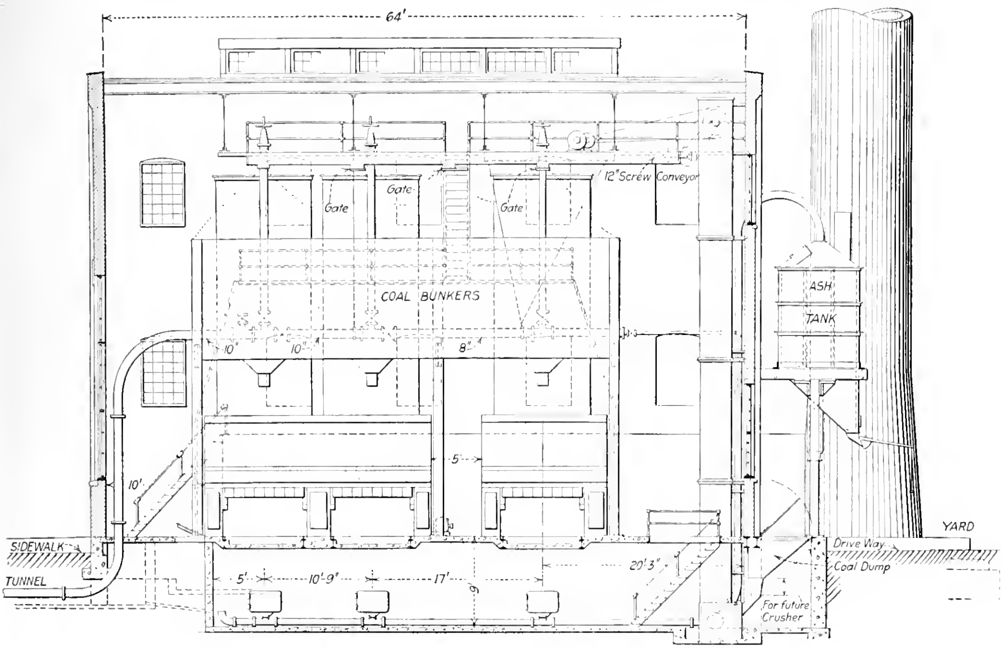


FIG. 3. LONGITUDINAL SECTION SHOWING GENERAL ARRANGEMENT

washed coal. This quality of coal requires less grate surface than an inferior grade as it contains less impurities, and as it is high in volatile more of it can be burned per square foot of grate than coals containing more ash or higher in fixed carbon. For these reasons and because an excellent stack had been provided, which is capable of producing a strong draft over the fire, a

produce a draft of 1 in. of water at the base for the four boilers and 1.1 for the three boilers now installed. For higher temperatures the draft will be slightly greater. While clean, the breeching should not cause a drop of more than 0.1 in. and the return from the breeching into the stack 0.05 in. Taking the boiler farthest from the stack, interference by the gases from the two other boilers will cause a drop of 0.1 in.—0.05 for each boiler. The right-angle turn of the gases in the breeching at the outlet of the boiler will cause a loss of 0.05 in., the damper [illegible] 0.05 in., the boiler 0.2 in. and the right-

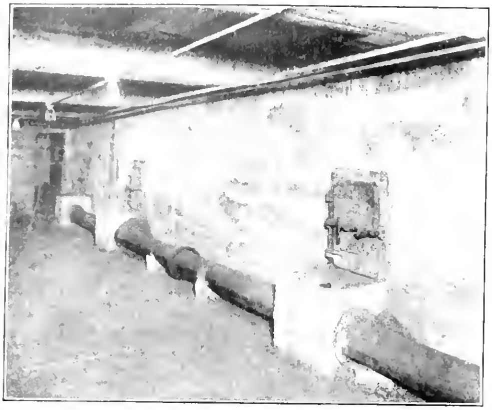


Fig. 4. Part of Ash-Removal System in Front of Ashpits

boilers approaching the stack the draft over the fire will be slightly higher, but with the three-wing dampers the intensity can of course be varied to suit the load conditions, thickness of fuel bed and the character of the coal.

It may be of interest to check the relative areas of stack, breeching and grate, and these will be compared on the basis of three boilers, as the fourth, when installed, will in all probability be held as a reserve unit. With an internal diameter of 7.5 ft., the stack has an area of 44.2 sq.ft., while the breeching, as previously stated, has 50 sq.ft. The breeching, then, is a trifle larger than the stack, as it should be, and its area bears a ratio to the connected grate surface of 1 to 5. This conforms with the average ratio adopted in recent practice. Each square foot of sectional area in the stack is intended to serve 5.9, or nearly 6, sq.ft. of grate, and each square foot of breeching 5.2 sq.ft. of grate. Per boiler horsepower, still considering the three units, the stack has an area of 0.0291 sq.ft. and the breeching 0.0333 sq.ft.

Figs. 2 and 3 indicate the arrangement of the plant, the layout and size of the steam piping, and the provisions made for handling coal and ashes. A feature worthy of notice is the walks, giving ready access to the top of the boilers, the steam header and the screw conveyor over the

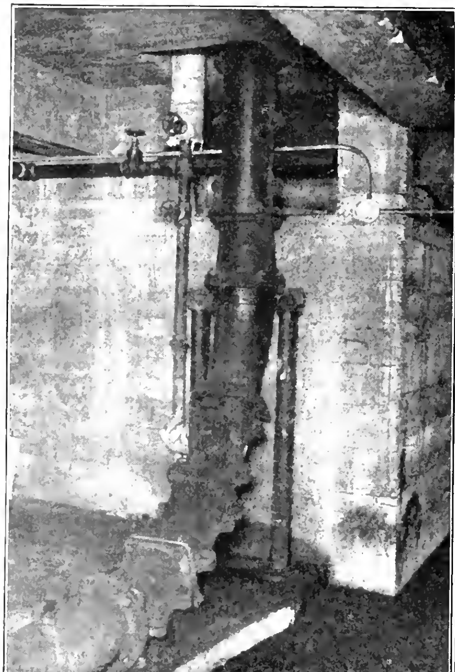


Fig. 5. Bend at Which Steam Nozzle Is Introduced

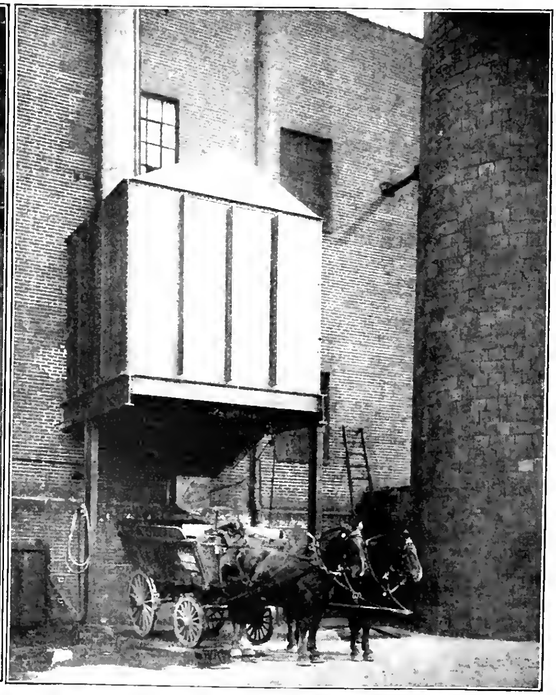


Fig. 6. The Receiving Tank for the Ashes

angle turn from the furnace up into the boiler, 0.05 in. The various drops total 0.6 in., and deducting this loss from 1.1 in. leaves a draft of 0.5 in. over the fire for the farthest boiler. With the fourth boiler installed the above draft would be reduced to about 0.35 in. For the

bunkers. As previously stated, coal is carted to the plant and dumped from the yard into a hopper shown at the right in Fig. 3. Provision has been made here for a coal crusher, which may be installed at a future date. From the hopper the coal slides into the boot of a bucket elevator and may be hoisted at the rate of 30 tons per hour. At the top of the boiler room the coal is transferred to a screw conveyor and may be dumped through any one of three gates into a suspended steel bunker of 175 tons' capacity. A separate spout for each boiler carries the coal to the hoppers of the stokers. All three stokers are eccentric driven from a shaft turned by a 5½-hp. motor.

Ashes are removed by a vacuum system using a steam nozzle to supply the motive power. As shown in Figs. 4, 5 and 6, this consists of about 100 ft. of 8-in. chilled cast-iron pipe having walls 1 in. thick, a steam nozzle and a tank to receive the ashes. The horizontal run in front of the ashpits is close to 50 ft. and the rise about 43 ft. The nozzle is located in the basement at the point where the pipe turns upward. Its location is shown in Fig. 5. The photograph was taken before the steam pipe leading to the nozzle had been fully covered. The far end of the ash pipe is left open, and when steam is turned on, air is pulled through the pipe at high velocity. Ashes raked from the pits into the pipe are carried along with the current of air, and when they pass the nozzle, are positively forced up into the tank by the jet of steam. Through a gate at the bottom of this tank the ashes are loaded into wagons and carted away.

The system was designed to handle 200 lb. of ashes per minute, or 6 tons per hour, with a steam pressure of 114 lb. at the nozzle. The nozzle is ⅝ in. diameter, and at the above rate will discharge against atmospheric pressure about 2000 lb. of steam per hour. Charging 22c. per 1000 lb. for steam, the cost for steam only per ton of ashes removed would be 6.4c. In a plant of this size additional labor should not be required to operate the system. The charge to add per ton for depreciation, interest on investment, etc., cannot be determined without knowing the amount of ashes removed per year or the life of the equipment, but at a rough estimate the total cost should not exceed 10 to 12c. per ton.

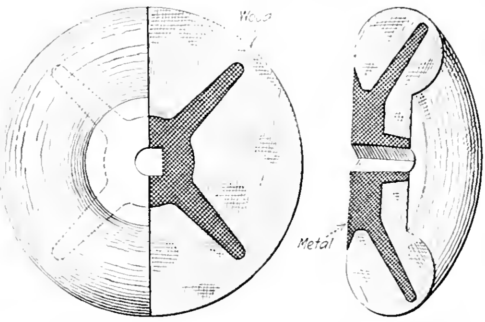
Feed water for the boilers comes from a 1000-hp. open heater in the old plant. It flows by gravity to the pumps, one of which is a 10x6x10-in duplex and the other a 12x7x12-in. simplex taken from the old equipment. The water lines are arranged to feed the boilers at either top or bottom, and for the present the water is fed at both points, with a view to reducing pulsations set up by the single pump. There is also a duplication of feed mains so that one pump may supply cold water for washing one or more boilers while the other is supplying the hot feed water as usual.

At present means for measuring water and weighing coal have not been provided. It is the intention, however, to install at an early date a water meter, coal scales below the bunker, a damper regulator and CO_2 apparatus. With these refinements so necessary for the keeping of accurate records, the plant, for its capacity, will be one of the finest in the country. Including building, stack, the fourth boiler and all equipment now installed, the total cost will reduce to $10 per boiler horsepower.

Ruebel & Wells, consulting engineers, of St. Louis, designed and erected the plant under the direction of Phillip Scheuerman, general manager of the brewery.

"Kantsplit" Valve Handle

One of the annoyances in a steam plant is the cracking and working loose from their metal seats of wooden valve handles such as commonly used on water-column



Showing How the "Kantsplit" Valve Wheel Is Made

cocks and the like. This trouble renders the handles useless and wooden handles have in many cases been replaced by metal, which, when used with steam, becomes hot and disagreeable to handle.

The "Kantsplit" handle seems to be so constructed as to prevent splitting and working loose from its bottom plate. The illustration shows how it is made. The handle is of birch or maple wood, which is used as a mold into which is cast a metal wheel, the spokes of which bind the fibers of the wood together and prevent it from splitting.

As the metal "freezes" to, and engages projections of, the top and bottom plate so as to make the finished handle one piece, the bottom plate cannot easily work loose.

The handle is inexpensive and is made by the Holton-Abbott Manufacturing Co., 61 Gorham St., West Somerville, Mass.

PRINCIPAL EQUIPMENT OF STIFEL BREWERY PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
3	Boilers	Vertical water-tube	500-hp.	Generate steam	150-lb. pressure, natural draft, stokers	Wickes Boiler Co.
3	Stokers	Chain grate	87-sq.ft	Serve boilers	Motor driven	Laclede-Christy Clay Products Co.
1	Motor	Direct-current	5½-hp.	Drive stoker shaft	110 volt, 1000 r.p.m.	Sprague Electric Co.
1	Ash removal system	Vacuum	8-in. pipe, ⅝-in. nozzle	Convey ashes from pits to tank	Steam pressure 114 lb. at nozzle, capacity 200 lb. per min.	Girtanner-Daviess Engineering & Contracting Co.
1	Coal handling system	Bucket elevator and screw conveyor	30 tons per hour	Transfer coal to bunker	Geared to motor, ratio 7 to 1	Stephens-Adamson Mfg. Co.
1	Stack	Radial tile	185-ft. high, 7½ ft. dia.	Serve boilers	1 in. draft at base	Wiederholdt Construction Co.
1	Pump	Duplex	10x6x10-in.	Boiler feed	150-lb. steam pressure	Epping-Carpenter Co.
1	Pump	Simplex "Hooker"	12x7x12-in.	Boiler feed	150-lb. steam pressure	Reliance Machine & Tool Works
2	Lubricators	Force feed		Serve boiler feed pumps		Hills-McCanna Co.
1	Heater	Open	1000-hp.	Heat boiler feed water	Exhaust steam	Harrison Safety Boiler Works

Figures on the cost of generation in small municipal plants are always interesting. The following are taken from the annual report of the 500-kw. municipal plant at Topeka, Kan., and include depreciation at 5 per cent., interest at 4 per cent. and taxes at 1.725 per cent.

Net cost per kw.-hr. at switchboard	$0.0165
Net transmission cost per kw.-hr.	0.00784
Gross cost per kw.-hr. at lamps, including all operating, overhead and fixed charges	0.0427
Net cost per arc lamp per year	24.31
Net cost per 100-watt series tungsten lamp per year	14.66

Interior Wiring for Lighting and Power Service--III

By A. L. Cook

SYNOPSIS—How to figure the sizes of branch circuits and feeders in lighting service for both direct- and alternating-current systems. The next installment will take up power circuits.

Two-Wire System

The two-wire system, previously described, is the simplest arrangement of lighting circuits. In laying out this or any other arrangement the voltage drop for the circuits must first be calculated. For direct-current circuits the drop can be calculated from the formula,

$$e = \frac{21.4 \times D \times I}{circ.mils}$$

where

e = Total drop in the two wires;

D = Distance in feet between the feeding point and the load; in other words, the distance one way;

I = Current in amperes.

To determine the size of wire for a given loss in volts the formula may be transposed to

$$Circ.mils = \frac{21.4 \times D \times I}{e}$$

The number 22 is sometimes used instead of 21.4 but the latter is satisfactory unless the wires are to be located in a very warm place. An example of the use of these formulas may be helpful. Suppose the feeder is No. 00 B. & S. (133,100 circ.mils.), the length of run 150 ft., and the load 50 amp.

$$e = \frac{21.4 \times 150 \times 50}{133,100} = 1.2 \ volts$$

If it is required to find the size of wire for this circuit with a loss of 1.5 volts,

$$Circ.mils = \frac{21.4 \times 150 \times 50}{1.5} = 107,000$$

Referring to Table 7 (page 642, May 11 issue) it will be seen that the nearest size is No. 0, which is slightly smaller than required.

While any direct-current two-wire circuit can be calculated by means of these formulas, it is more convenient to use some form of chart. The one printed in Fig. 7 is based upon the formula already given and is a modification of a chart devised by R. W. Stovel and N. A. Carle (see *The Electric Journal*, June, 1908). If it is desired to find the drop for the feeder already calculated, start at 50 amp. on the lower left-hand side and follow vertically until this line crosses that for 00 wire; then pass horizontally to the right to the line marked 150 ft. and follow down vertically and read 1.2 volts.

To determine the size of wire as in the second problem, start with 1.5 volts at the lower right-hand side and follow up vertically to the 150-ft. line; then horizontally to the left to the line for 50 amp., which also crosses the No. 0 line at this point.

Suppose it is desired to find the drop when 6 amp. is carried by a No. 12 wire for a distance of 100 ft. The chart does not give a value for 6 amp., but the drop can be figured for 12 amp. and then divided by 2, since it will be half as great as for 12 amp. Using the chart, we obtain 4 volts, so the drop for 6 amp. would be 2 volts.

If it is desired to find the drop for 125 amp. carried on a 300,000-circ.mil cable a distance of 200 ft., the position of the 125-amp. line will have to be estimated between the 100- and the 150-amp. lines. Carrying this up to the 300,000-circ.mil line and then across to the right and down as before will show a drop of 1.8 volts.

Returning to the original problem, compare the size of wire required for 240 volts with that for 120. If the load is 50 amp. at 120 volts, this is $50 \times 120 = 6000$ watts. With the same load at 240 volts, the current would be $6000 \div 240 = 25$ amp., or one-half that for the lower voltage. Hence, the same percentage drop can be allowed for the higher voltage; that is, if 1.2 volts are allowed in the first case, 2.4 in the second will give satisfactory operation. From the chart it will be found that the size of wire required is No. 5. For 120 volts, therefore, No. 00 wire having 133,100 circ.mils is required, and for 240 volts to transmit the same power, only 33,100 circ.mils, or ¼ the size. No. 5 wire is a size not ordinarily used, so that No. 4 would probably be employed, but the saving due to the higher voltage is apparent.

If the load consists entirely of incandescent lamps the current can be determined either by dividing the total watts on the feeder by the voltage of the lamps or by multiplying the current per lamp (see Table 1, page 602, May 4 issue) by the number of lamps. With arc lamps it is best to multiply the current taken by each lamp by the number of lamps. For alternating-current circuits, the same chart may be used if the two wires of a circuit are run in the same conduit and the load consists of incandescent lamps. Alternating-current arc lamps have a power factor of about 0.70 or 0.65, and if a large load of these were to be carried on a feeder the drop would be greater than for direct-current and the method employed for calculating motor circuits, as described later, should be used. For wires not larger than No. 4 the chart can be used without modification for circuits carrying alternating-current arc lamps. For exposed work, where the wires are separated several inches, the drop on the circuits would be greater than for direct current. In the case of branch circuits No. 10 or smaller, the increased drop is small even with arc lamps; consequently, the direct-current chart can be used. For the feeders, however, the drop should be calculated by the method used for motor circuits. If a feeder carries both arc and incandescent lamps, it is not correct to add the two circuits together. This is because of the power factor.

Branch Circuits

The wiring of an electric-light installation is divided into branch circuits, to which the individual lights are connected, and the feeders which supply the branches.

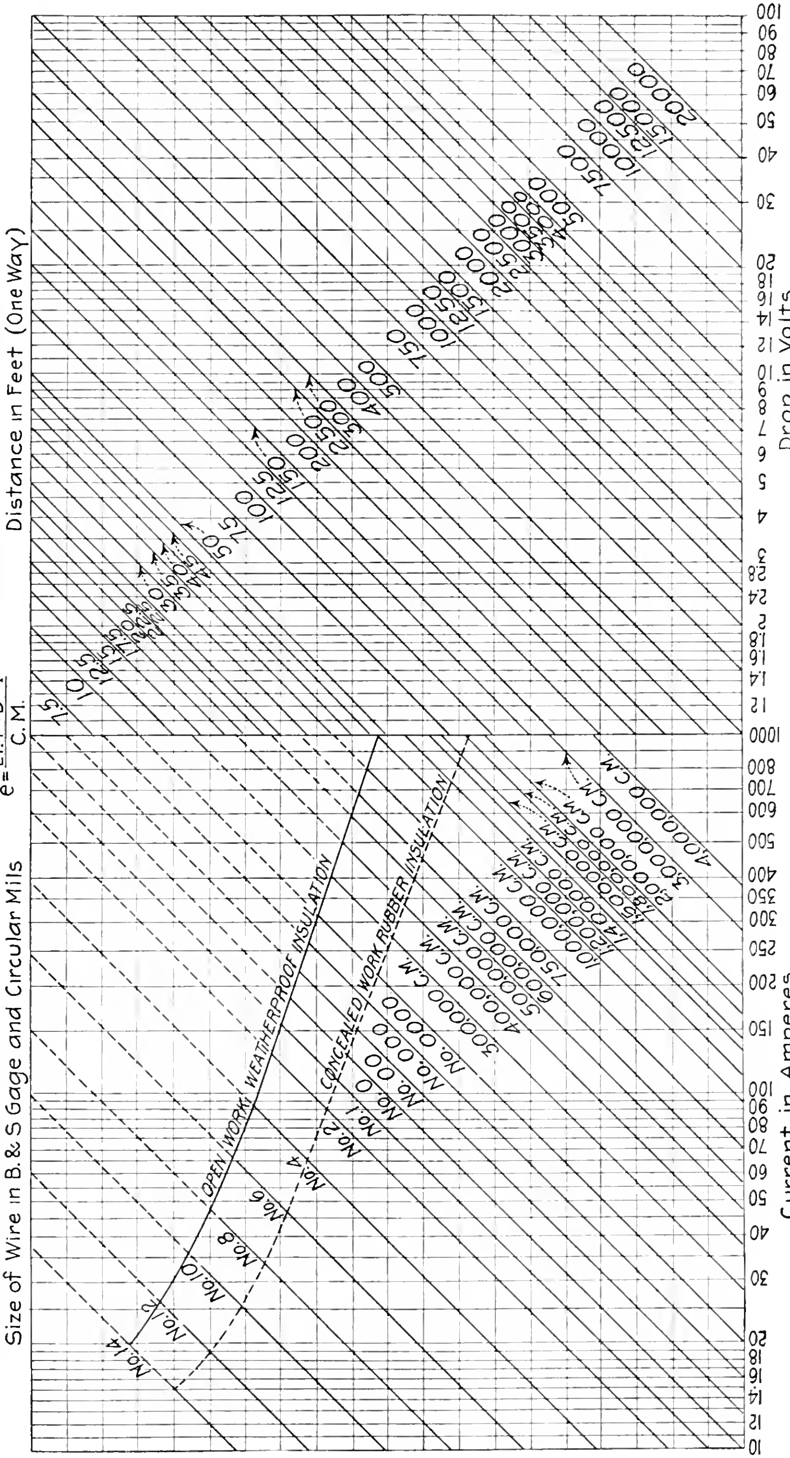


Fig. 7. Stovel-Cable Wiring Chart for Direct-Current Circuits

Sometimes, a feeder supplies more than one group of branch circuits, in which case there are feeders and sub-feeders, or mains, feeding the individual groups. The arrangement of circuits varies to suit conditions. Fig. 8-a shows a scheme sometimes used in mills where the cost must be kept down. Here, mains are run the length of the room and the lights tapped directly from them through individual fuses in the rosettes, no branch cir-

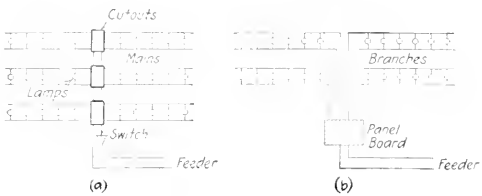


Fig. 8. Arrangement of Branch Circuits

cuits being used. Its principal objections are lack of control of the individual circuits and variation in voltage at the lights, as those nearest the fuse blocks may have a voltage 2 or 3 per cent. higher than those at the extreme end. A modification of this arrangement is shown in Fig. 8-b. Here the lamps are arranged in groups taking not more than 660 or 1320 watts, depending on the kind of outlet, and each group is wired separately to a panel-board. This has the advantage of individual control of the groups of lamps and while more expensive is used extensively, particularly with large-sized lighting units.

Fig. 9 shows an arrangement frequently used for small office buildings and sometimes for factories. Here there is a panel-board on each floor, from which the branch circuits are run. This has some of the objections found in Fig. 8-a since the drop to the panel on the top floor will be greater than that to the first floor. However, it is fairly satisfactory for buildings of four stories or less, particularly if the load on each panel is relatively small. In Fig. 10 is shown a modification of this arrangement which results in much better voltage regulation, since the drop to each panel can be made about the same. A further modification would provide one feeder for each panel, but this is justified only when the load on the panel is very large. As a rule, not more than three panels should be placed on one feeder.

It is assumed that the number, size and location of the outlets have been settled as previously described. If control switches are to be provided, they should be located carefully. For offices and similar places they should be placed about 4 ft. from the floor, near the entrance door on the lock side, so as not to be hidden when the door is open. In factories they may be located on columns or side walls and should be grouped as much as possible, to save wiring. When the tenants are supplied with meters they should be placed near the panel-board if possible, or in the various offices. Meters are not commonly used, owing to the cost, the usual method being to charge each tenant a flat rate for lighting. The panel-board should be as near the center of the load which it is to supply as possible, as this results in more uniform voltage on all the lamps. For office buildings the best location is in the halls, the panels being, as far as possible, at corresponding points on the various floors, so as to give direct vertical runs for the feeders. For factories they should be near the center of the room, if feasible, and for very large areas the room may be divided into two or more parts and a panel provided near the center of each part. The number and location of panels are fixed by the number of branch circuits and their lengths. It is unwise to use long branch circuits because of the high drop, and for uniformity in wiring it is generally best to settle on one size of wire for all branch circuits irrespective of their lengths.

As a guide in locating the panel, it is convenient to know the length of branch which can be used and not exceed 1.5 per cent. drop. Table 8 gives these values for the sizes of wire ordinarily used for branches, with the maximum load allowable and also with smaller loads. When using this table the distance given is that to the center of the load. For example, if there were 8 outlets of equal size and spaced 10 ft. apart, the center of load would be at the center of the row; that is, a distance of 35 ft. from one end. If from the panel to the first lamp were 20 ft., the distance to be used in calculating the drop would be 55 ft., and it would be assumed that the entire load on the branch was to be carried to that distance. If the units are not all the same size the center of load would shift toward the larger ones. To calculate the center of load in this case multiply the distance from each unit to the panel-board by the number of watts or amperes for that unit, add these values together and divide by the total watts or amperes in the circuit; the result will be the distance to the center of load. With the aid of this table the location of the panel-board may be roughly checked.

The maximum load in watts which may be carried by one branch has already been specified, but it is also necessary to check the number of sockets on each branch. For a 660-watt branch not more than 16 will be allowed, and for a 1320-watt branch 32 is the largest number. These rules apply to the circuits where the lamps do not have individual fuses, but only fuses for the entire group on one branch. These rules would allow the use of sixteen 40-watt lamps in the first case, and thirty-two in the second. Since the lamps are usually larger than this, the number of outlets would generally be less. Sometimes local rules modify these general rules, so it

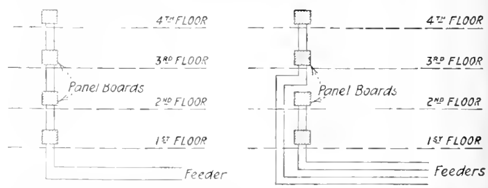


Fig. 9. Arrangement for Small Office Buildings and Factories

Fig. 10 Drop to Each Panel about the Same

is always best to obtain information on this point from all parties interested. In counting the number of sockets, plug outlets for portable lamps must be included. It is important to have each branch circuit fully loaded, as each additional branch which must be provided for on the panel-board makes an additional cost of three or four dollars in the panel; on the other hand, it is frequently necessary to allow for possible extensions of the branch or an increase in the size of the lamps. The extent of this allowance will vary. Thus, an office building, where the lighting requirements might be very different with different tenants, should be more liberally designed than factory lighting, where the requirements are fairly well fixed. For the latter the branches may be loaded to 90 per cent. or more of their capacity, while for the former it is best to allow only 80 to 90 per cent. load.

After the branches have been sketched in, the size of wire should be determined. It is common to use No. 14 for branches, but reference to Table 8 will show that the lengths must be rather short if the allowable drop of 1.5 per cent. is not exceeded. For the usual runs in factories and office buildings No. 12 wire will be found more suitable; and for circuits with 1320 watts, No. 10 may have to be used. It is unnecessary to check all the branch circuits; one or two from each panel, which appear to have the greatest drop, being checked by means of the chart or Table 8. If it is found that the allowable drop is greatly exceeded, a larger wire may be used or a rearrangement of circuits made. If this load is decreased, the number of circuits will be increased, and thus affect the cost of the panel. Therefore, it will generally be preferable to increase the size of wire. In any case the branch circuit should be fused to its maximum capacity as follows:

TABLE 8—BRANCH LIGHTING CIRCUITS

Maximum length of circuit for 1.5 per cent. drop.

Size, B. & S. Gage	Distances in Feet* — 120 Volts — 12 Amp.	10 Amp.	6 Amp.	5 Amp.	240 Volts — 6 Amp.	5 Amp.	3 Amp.	2.5 Amp.
14	29	35	58	70	116	138	232	276
12	46	55	92	110	184	220	360	440
10	73	87	146	174	292	348	...	...
8	116	139	232	278	464	...	...	...

*Note that the distance given is in each case to the center of load and not to the end of the run.

	125 Volts or Less	125 to 250 Volts
660-watt circuit...........	10 amperes	5 amperes
1320-watt circuit..........	20 amperes	10 amperes

Referring to the example given in Table 3 (see page 604, May 4 issue), let us apply these rules to the machine-shop floor. The natural location of the panel would be on one of the columns on the center-line of the room. The column nearest the center would have four bays on one side and five on the other, giving a maximum length of branch circuit of about 112 ft. In this case, it would be best to run the circuit with the length of the room, to facilitate the control, although this compels crossing the beams forming the bays. There would be a maximum of 10 lamps in one row on one side of the panel-board, the distance to the first unit on the farthest row being about 35 ft. and that between end units 67.5 ft.; hence, the distance to the center of the load is $\frac{67.5}{2} + 35 = 68$ ft. 9 in. The load is $\frac{10 \times 100}{120} = 8.3$ amp.

TABLE 9—LOADS ON PANELS

Floor	A Panel No.	B Circuits in Use	C Total Circuits Provided	D Load in Watts	E Amperes Load at 120 Volts	F Maximum Amperes
Basement .	1	4	6	2,160	18	30
First floor.	2	12	16	10,800	90	160
Second floor	2	12	16	10,800	90	160
Third floor.	4	8	10	3,600	30	50
Fourth floor	5	12	16	10,800	90	160
Fifth floor.	6	12	16	10,800	90	160

A No. 12 wire, carrying this load, would give a drop of 1.83 volts, or 1.53 per cent., which is satisfactory. The loads on the panels can now be obtained by adding those on each branch, each plug outlet for a portable light being figured at 50 watts. The size of the panels will be fixed by the number of circuits, plus an allowance for extensions. For panels up to 10 circuits, at least 2 spare circuits should be allowed and for 10 to 20 circuits at least 4 should be provided. These computations, for the example previously discussed, are given in Table 9.

When locating the service connection, or switchboard, care should be taken to place it as nearly central to the load as possible. There is generally little choice, since the board must be located in the basement if the service is underground, and if overhead it must be as close as possible to the point of entrance of the wires. If the supply is from a private power plant the choice of location is influenced by other considerations. The place chosen in any case should be as clean and dry as possible, and provision should be made for preventing access to the board by unauthorized persons.

Feeder Systems

After determining the loads on the panels, it is necessary to plan the feeder system according to the schemes

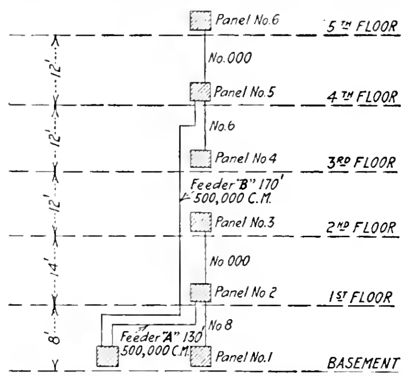


Fig. 11. Riser Diagrams for Factory Building

shown in Figs. 8, 9 or 10. An arrangement similar to Fig. 10 is convenient where it is desirable to provide for cutting off the power from certain sections without interfering with the rest of the lighting. For economy it is desirable to have the load on each feeder as great as possible, but there is a limit to the size of conductor which should be used, particularly where two or three wires are carried in one conduit. For office buildings, particularly, it is difficult to conceal a conduit larger than 2½ in. and to take care of the long-radius bends required for larger conduit. In general, a wire larger than 500,000 circ.mils should not be used. For the system shown in Fig. 9, however, the size may run larger than this, particularly for a two-wire 120-volt system. The feeder system should be planned in a preliminary way, bearing these general statements in mind, a sketch being made showing each panel-board with its load in amperes and the various feeders with their lengths and loads. The load on the feeder should be taken as the total load actually connected to the panels supplied by that feeder. For the example given in Table 9, the actual load in watts is given in column D and the load in amperes is calculated for 120 volts using a two-wire system. Fig. 11 shows the arrangement of feeders supplying the panels.

A reasonable allowance should be made for extensions and for an increase in the lighting load. In any case, the feeder should be sufficient to allow at least 600 watts per branch, or, if the arrangement is such that the larger [illegible] are used 1200 watts per branch may be allowed; this should include the spare circuits. The feeder chosen should then be checked to see that the drop, with the actual load, does not exceed the allowable amount as specified previously. If the drop is too great the feeder must be increased in size.

Column F in Table 9 gives the maximum loads for the example chosen. Referring to Fig. 11, calculate the size of feeder *B*. The length is 170 ft., the maximum load 370 amp. and the actual load 210 amp. This requires a 500,000-circ.mil cable if rubber wire is used. The drop with 210 amp. would be 1.53 volts. The maximum allowable drop, as previously specified, is 1.3 per cent. for a feeder. This is 1.56 volts for a 120-volt system; hence, the size of cable chosen is satisfactory. In this case, since the subfeeders supplying panels 4 and 6 are short, practically all the drop is in the feeder and 2 per cent. could be allowed if necessary. If the drop in the branches is less than 1.5 per cent. it is not satisfactory to add the amount saved in the branch circuit to

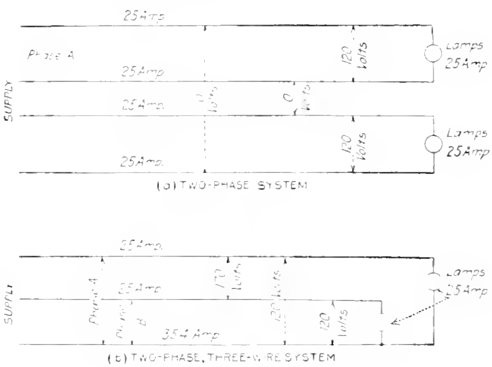


FIG. 12. CURRENT AND VOLTAGE RELATIONS IN TWO-PHASE SYSTEM

the feeder drop, thus making it more than 2 per cent.; instead it should be kept within this limit.

If the total feeder drop exceeds a proper value it must be decreased by increasing the size of feeder or subfeeder. Generally, it is best to increase the main feeder leading to the first panel, as the drop on the subfeeders running to the other panels is usually small. The drop in the subfeeders should be about 0.7 per cent. and in the main feeder 1.3 per cent. When more than one panel-board is carried on a feeder, as in Fig. 10, the subfeeders will be smaller than the main feeders, and would therefore not be protected by the fuses on the latter. To protect these subfeeders, the panel is provided with the necessary fused branch circuits to which they may be connected, these circuits being connected to the main feeder where it enters the panel. With the arrangement of Fig. 9, the size of feeder would be decreased for the panels on the lower floors, the feeder entering the panel-board at the bottom and leaving at the top, and fuses must be provided at the top to protect the subfeeder above. The panel busbars must be large enough to carry the entire current of the panel and the subfeeders connected to it. When the sizes of wires have been checked, the sizes of conduit can be determined by means of Table 6 (see page 641, May 11 issue), bearing in mind that both wires of a circuit must be in the same conduit if alternating current is used.

THREE-WIRE SYSTEM

Calculation of a three-wire system is much the same as that of a two-wire, so that only the points of difference will be discussed. As long as the load is the same on each side of the system there will be no current in the neutral. If, however, the load on the positive side were 20 amp. and on the negative 25, there would be 5 amp. in the neutral. If all the load were removed from the positive side, the current in the neutral would be the same as in the negative wire. Since there is always a chance of the load being different on two sides of a three-wire system, the neutral must be sufficiently large to carry the difference, and is generally made the same size as the outside wires. This is not required by the "National Electric Code," except in certain cases, but it is good practice. If the neutral circuit is opened when the load on each side is the same, there will be no change in the voltage across each group of lamps; but if the negative side, for example, has a larger load than the positive, the lamps on the former would receive less than 120 volts and those on the latter more; hence, these lamps might burn out. Such a case might occur if a fuse in the neutral should blow.

The location of outlets would be the same as for the two-wire system, since the branch circuits are two-wire in any case. The location of panel-boards and switchboards is determined in the same manner, and the arrangement of the circuits may be similar to those shown in Figs. 8, 9 or 10, using three-wire mains and feeders instead of two-wire. The layout of the branch circuits would be made in the manner previously described, and the drop would be limited to about 1.8 volts, since 120 is the voltage for the branches. The branch circuits are so connected to the panels as to give practically half the total load on each side; in other words, to produce a balanced system. The actual load in each outside wire of the feeder would, therefore, be one-half the total for all the lamps supplied from that panel.

The determination of the feeder sizes is governed by the same rules as for the two-wire system. The actual loads in the outside wires would be the sum of the loads for all the panels supplied by that feeder. The maximum load should also be determined by allowing 5 or 10 amp. for each branch connected to either side of the circuit. When these loads have been determined for each main feeder and subfeeder, the size of wire may be chosen by means of Table 7 (see page 642, May 11 issue), using the maximum loads as before. The feeders should then be checked for voltage drop with the actual load. The voltage loss allowable in the feeders is 2 per cent. of the voltage to the neutral, for each side of the system. Thus, if a 120-240 volt system is used the drop for each side of the system may be 2.4 volts. With a balanced load, all of this occurs in the outside wires. If the load were unbalanced, there would be some drop in the neutral, but in any well-designed system this is so small that it may be neglected.

Care should be taken when using the chart, since it gives the drop for a length of wire twice that marked on the various lines, which is the length of run. If the current in the outside wire of a two-wire feeder is used, and the length taken is that for the feeder, then the voltage drop obtained by the chart should be divided by 2 to obtain the drop in a single wire. After the sizes of the outside wires have been determined the neutral may be taken the same, and then the conduit sizes are determined, using one conduit for all three wires if alternating-current is employed.

Referring to the previous example, feeder B would have a maximum load of 185 amp. and an actual load of 105. A drop not exceeding 2.4 volts can be allowed in each of the outside wires, and to carry 185 amp., No. 0000 cable must be used. The drop on a two-wire circuit having a length of run of 170 ft. is 1.8 volts; hence, that for 170 ft. of wire is 0.9 volt, and this is the drop on each of the outside wires of feeder B. The actual voltage loss on the lamps, however, is only 0.9 volt, since they are affected only by the drop in the wires to which they are connected.

Sometimes a three-wire system is arranged so that it can be changed to a two-wire by connecting the outside wires together at the switchboard. This transforms it into a 120-volt two-wire system. If this is to be done, each side should be calculated as a two-wire system with one-half load, the outside wires being made of the size thus determined and the neutral double this size. Sometimes, this type of system is calculated as a three-wire, and then the neutral is made twice the size of the outside wires, but this arrangement results in a higher drop at the lamps than when it is run as a three-wire system.

Three-Phase System

Three-phase systems are sometimes used for lighting, but should be avoided for such service if possible. The three-phase system with three wires takes considerably more copper than the three-wire system, while the four-wire arrangement saves in copper at the expense of added complication in the panel-boards. The branch circuits would be two-wire, as in the previous arrangements.

After the sizes of feeders have been determined from Table 7 by using the maximum load, the drop should be checked by means of the chart. Allowing 2 per cent. drop, this amounts to 2.4 volts across the lamps for a 120-volt system. The allowable drop for each wire is 0.58 times 2.4 volts, or 1.39, and the size should be determined, using the actual load previously found. In using the chart it should be remembered that it gives a drop for a two-wire circuit, so the voltage drop obtained should be divided by 2. The chart can be used if the three wires of a feeder are all in the same conduit; if not, other methods to be described later may have to be used. If the three-phase four-wire system is used, the branch circuits would be divided into three equal parts as before, and connected between the three main wires and a common wire called the neutral. The current in each of the main wires would be the total for all the lamps connected to that wire, and that in the neutral would be zero as long as the current in all the main wires was the same. The actual and maximum currents would be determined as before, using the branches connected to one of the outside wires. If the allowable drop in the feeders is 2 per cent., this applies to each main wire, so the drop in each of these wires for 120 volts across the lamps would be 4.8 volts. The wire size can be obtained in the same manner as before and the neutral made the same size as the other wires.

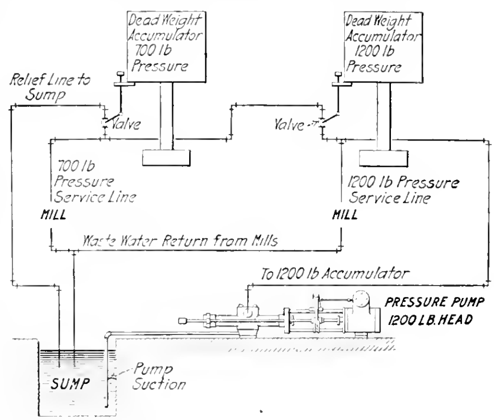
The two-phase system, for use in lighting, is open to the same objections as the three-phase, if all the feeders and subfeeders are made two-phase. Either of the plans shown in Fig. 12 may be used. If the arrangement in *a* is used each phase can be treated independently and figured as a simple two-wire system, but with arrangement *b*, the current in the common wire is obtained by adding together the currents in the two outside wires and multiplying by 0.71. When the load is practically the same on each side, the voltage drop can be computed readily. First calculate the drop in either outside wire with the current previously determined, then the drop in the common wire which would be caused by this same current. Add these together and let the result be represented by A. Then calculate the drop in the common wire due to the current from the other outside wire, and let this be B. The total drop is $\sqrt{A^2 + B^2}$.

In general, the three-phase or the two-phase systems are not well adapted for interior wiring. If either of these systems must be depended upon as a source of supply, it is better to arrange the circuits as a single phase, two-wire or three-wire system.

Two-Pressure Hydraulic Service

By A. D. Williams

Manufacturing operations at the plant of the Firestone Rubber Co., Akron, Ohio, require pressure water at 700 and 1200 lb. per sq.in., and the method adopted to obtain this service is shown in the illustration. Two dead-weight loaded accumulators are used, and the pumping plant is



Arrangement of Accumulator Piping

designed to deliver to the higher-pressure accumulator and to hold it at the highest point of the stroke, delivering water to supply the demand for both pressures. As soon as the high-pressure accumulator rises its full height it opens a valve and a portion of the water flows to the low-pressure accumulator and this, when it reaches the top of its stroke, opens a relief valve, permitting the surplus water to return to the sump or sewer.

To prevent excessive waste of pressure water the steam supply to the pressure pumps is shut off automatically when the low-pressure accumulator rises to a sufficient height to open the relief valve. The pumps are automatically started when either the low- or high-pressure accumulator drops a certain amount. The starting device is so arranged that it will act to start the pump if the high-pressure accumulator drops while the low-pressure accumulator still remains at its highest position. This provision is necessary, as the demand for pressure water is variable upon each of the two pressure systems and a heavy demand might be made on the 1200-lb. line at a time of no demand on the 700-lb. line. In practice the arrangement works out nicely, maintaining full pressure upon both lines and taking care of all service demands.

Pressure water is supplied to the system by three pumps. One is a 13&26x1½x24-in. outside-packed plunger pump with a Corliss cross-compound steam end and flywheel. At present this machine is operating noncondensing, but later is to be connected to a condenser. It will deliver 300 gal. per min. at 50 r.p.m. There are two duplex-compound outside-packed plunger pumps, 12&18x5¾x16 in. These comprised the first hydraulic-service installation, the flywheel pump having been added within the year.

Internal-Combustion Engine Dimensions

By H. L. Watson

SYNOPSIS—A chart for graphically determining the speed, bore and stroke for a given type and size of internal-combustion engine according to average American practice.

During the summer of 1912 there appeared in Power a series of articles by Messrs. Ulbricht and Torrance upon "American Practice in Rating Internal-Combustion Engines."* These represented the results of an extensive thesis made at Cornell University under the direction of Professors Diederich and Hirshfeld, the data being given in the form of curves from which empirical equations were obtained. By means of these equations it is possible to determine the cylinder bore, stroke and revolutions per minute necessary for an engine of any desired type, fuel, and power; four-stroke-cycle stationary engines only being considered. These equations are given in Tables 1 and 2.

It occurred to the writer that these equations might be plotted upon one sheet, thus reducing the work necessary for the solution of a problem. Upon such a chart, herewith shown, all curves denoted by letters refer to the type of engine, and those denoted by Roman numerals refer to the fuel used. To further distinguish them the curves are represented by different kinds of lines.

TABLE 1

Relation of d^2ln and b.hp. for Various Fuels	Remarks
Producer gas $d^2ln = 18{,}500\ (b.hp. + 2)$ $d^2ln = 17{,}900\ (b.hp. + 1)$ $d^2ln = 20{,}600\ (b.hp. + 4)$	Average—all values Single-acting—horizontal and vertical Double-acting—horizontal
Natural gas $d^2ln = 15{,}200\ (b.hp. + 5)$	Average—all arrangements
Illuminating gas $d^2ln = 15{,}700\ (b.hp. + 2)$	Single-acting—horizontal and vertical
Blast-Furnace Gas $d^2ln = 21{,}000\ (b.hp. - 5)$	Double-acting—horizontal
Oils and distillates $d^2ln = 21{,}875\ (b.hp. - 0.75)$	Single-acting—horizontal and vertical
Gasoline $d^2ln = 16{,}400\ (b.hp. - 0.5)$	Single-acting—horizontal and vertical

TABLE 2

Type of Engine	Relation of n to b.hp.	Relation of d to l	Relation of d to d^2l
Vertical Single-acting	$n = \frac{5368}{b.hp. + 14} + 176$	$d = 0.91\ (l) - 0.45$	$d^3 + 0.45d^2 = 0.91\ (d^2l)$
Horizontal single-cylinder Single-acting	Gasoline $n = \frac{3020}{b.hp. + 9} + 128$ Gas $n = \frac{6580}{b.hp. + 21} + 131$	$d = 0.667\ (l) + 0.4$	$d^3 - 0.4d^2 = 0.667\ (d^2l)$
Horizontal tandem Single-acting	$n = \frac{3650}{b.hp. + 4.5} + 156$	$d = 0.772\ (l) + 0.55$	$d^3 - 0.55d^2 = 0.772\ (d^2l)$
Horizontal Double-acting	$n = \frac{9500}{b.hp. + 29} + 72$	Natural Gas $d = 0.533\ (l) + 4$ Producer Gas $d = 0.667\ (l) + 2$	Natural Gas $d^3 - 4d^2 = 0.533\ (d^2l)$ Producer Gas $d^3 - 2d^2 = 0.667\ (d^2l)$

Procedure
1. Assume type of engine, b.hp. and fuel.
2. Obtain (d^2ln) from Table 1.
3. Obtain (n) from Table 2, col. 1.
4. Obtain (d^2l).
5. Obtain (d) from Table 2, col. 3.
6. Obtain (l) from Table 2, col. 2.

In all cases b.hp. = brake horsepower per cylinder end.
d = cylinder diameter in inches.
l = length of stroke in inches.
n = revolutions per minute.

*This series was copyrighted by T. C. Ulbricht and C. E. Torrance.

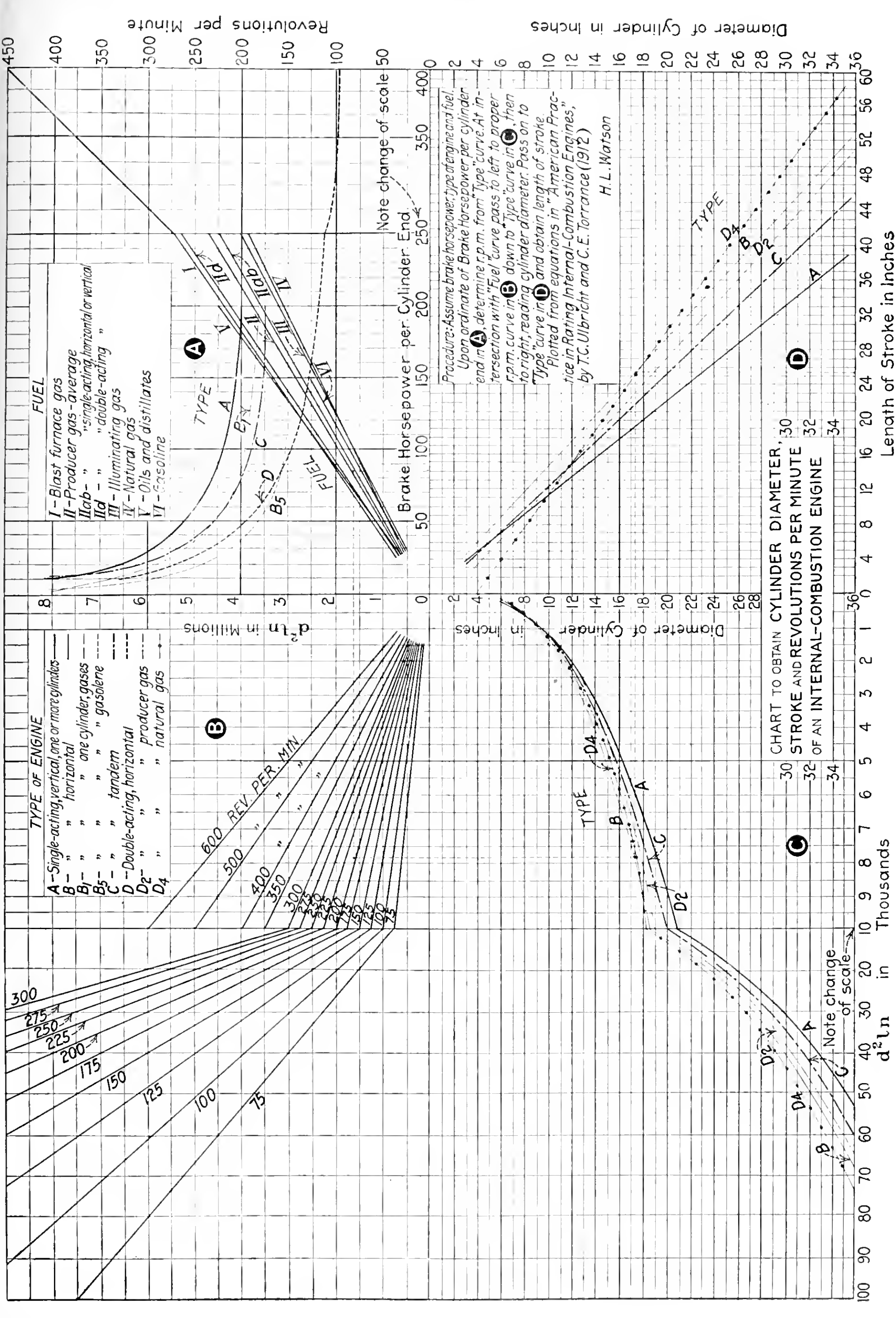


CHART TO OBTAIN CYLINDER DIAMETER, STROKE AND REVOLUTIONS PER MINUTE OF AN INTERNAL-COMBUSTION ENGINE
Procedure: Assume brake horsepower, type of engine and fuel. Upon ordinate of Brake Horsepower per cylinder end in (A), determine r.p.m. from "Type" curve. At intersection with "Fuel" curve pass to left to proper r.p.m. curve in (B) down to "Type" curve in (C), then to right, reading cylinder diameter. Pass on to "Type" curve in (D) and obtain length of stroke. Plotted from equations in "American Practice in Rating Internal-Combustion Engines," by T.C. Ulbricht and C.E. Torrance (1912)
H.L. Watson
FUEL
I - Blast furnace gas
II - Producer gas - average
IIab - " " "single-acting, horizontal or vertical
IId - " " "double-acting "
III - Illuminating gas
IV - Natural gas
V - Oils and distillates
VI - Gasoline
TYPE OF ENGINE
A - Single-acting, vertical, one or more cylinders
B - " " horizontal
B1 - " " " one cylinder, gases
B5 - " " " " gasolene
C - " " tandem
D - Double-acting, horizontal
D2 - " " " producer gas
D4 - " " " natural gas
Revolutions per Minute
Brake Horsepower per Cylinder End
Note change of scale
Diameter of Cylinder in Inches
Length of Stroke in Inches
d²Ln in Millions
d²Ln in Thousands
600 REV. PER MIN.
TYPE
A
B
C
D

The expression giving the power of an engine per cylinder end is

$$B.hp. = \frac{PLAN}{33{,}000 \times mechanical\ efficiency}$$

where

P = Mean effective pressure;
L = Stroke in feet;
A = Cross-sectional area of cylinder in square inches;
N = Number of explosions in that cylinder end per minute.

It may thus be said that the power is a function of d^2ln.

where

d = Diameter of cylinder in inches;
l = Stroke in inches;
n = Revolutions per minute.

The equations of the relations between b.hp. per cylinder end and d^2ln for different fuels have been replotted in the upper right-hand section of the chart. The curves between brake horsepower and revolutions per minute for engines of different types have also been plotted in this section, while those showing the relations between bore and stroke for engines of different types have been replotted in section D.

It was necessary to plot curves giving the relations between d^2ln and d. This was done by first drawing in section B a series of curves between d^2ln and d^2l for various r.p.m., and then plotting in section C curves showing the relations between d^2l and d for the different types of engines. The equations of these latter curves were determined as follows:

From Table 2, col. 2 (for a vertical, single-acting engine)

$$d = 0.91\,l - 0.45, \text{ or } l = \frac{d + 0.45}{0.91}$$

whence

$$d^2l = \frac{d^3 + 0.45\,d^2}{0.91}$$

Proceeding in the same manner with the remaining types of engines, the set of equations in column 3 was obtained.

The use of this chart is best illustrated by an example. Let it be desired to determine the revolutions per minute, stroke and bore for a single-acting, horizontal, single-cylinder engine using producer gas and developing 85 b.hp. per cylinder end.

First note the legends in the chart for the curves corresponding to the type of engine and fuel assumed. Upon the 85-b.hp. ordinate in section A note the intersection with the "type" curve, B_1, giving (to the right) the r.p.m. as 200. From the intersection of this same ordinate with the "fuel" curve, H_{ab}, pass horizontally to the left to the intersection with the line in section B representing 200 r.p.m., thence downward to the curve B in section C; from this point pass horizontally to the right, finding the bore of the cylinder to be 17¼ in. By proceeding further to the right to the intersection with curve B in section D, we will find the stroke of the engine to be approximately 25½ in.

It must be remembered that these curves have been drawn through many values plotted and, as such, represent the average size and speed for an engine of the type and power desired, built according to American practice, as set forth in the original article.

Franklin Cylinder Oil "Carburetor"

Engineers have learned by experience that if cylinder oil is fed through a pipe connection that just passes through the shell of a steam pipe, the oil is not well distributed in the engine cylinder to which the pipe is connected. A number of atomizing devices have been

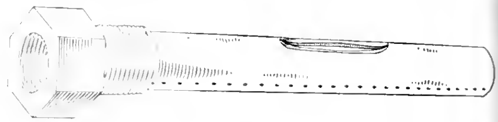


Fig. 1. The Atomizing Tube

used, such as perforated pipes that extend part way across the inside of the steam pipe.

What is known as the Franklin oil "carburetor" is made by the Franklin Oil & Gas Co., Bedford, Ohio. It is designed to atomize the oil so that it will mix with the steam before it enters the cylinder.

The device is made with a nut having a threaded shank with a hollow tube extension that is plugged at the inner end. The top of the tube is slotted and two rows of small holes are drilled in the tubes about one-quarter way around from each side of the top slot. Holes are also drilled in the plugged end. The heated, atomized oil is discharged through the holes. Fig. 1 illustrates the idea.

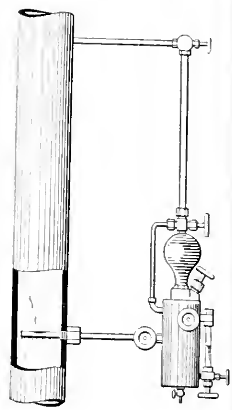


Fig. 2. "Carburetor" as Used with a Lubricator

The "carburetor" is screwed into the steam pipe with the slotted side up when at its permanent position. The lubricator or forced feed pump discharge pipe is screwed to the thread inside the nut which is outside of the steam pipe. Fig. 2. The appliance is made in three sizes—⅜-, ½- and ¾-in. standard pipe threads, and of different lengths to meet the requirements of the steam-line diameter.

Branded Waste

While waste is one of the minor items of power-plant supply, a saving of any considerable percentage of the aggregate amount spent for this commodity in one year would be a very tidy sum. The Royal Manufacturing Co., of Rahway, N. J., extensive dealer in cotton and woolen waste, is making an attempt to standardize the trade. It has divided its wares into twelve branded grades, of which samples are furnished in a folder. The waste is bought by its branded name, and the packages are guaranteed to contain not over a certain amount of tare and to be of accurate weight, so that the payment for a lot of hoops and bagging at waste prices, or the padding of an order 30 to 50 per cent., is avoided.

The Why's of Boiler Draft

By C. F. Hirshfeld*

SYNOPSIS—Draft through a boiler simply explained by comparison with a pipe carrying water under pressure. The stack is considered as a pump and its action explained from this viewpoint.

Despite the fact that much has been written on the subject of draft and its significance in boiler practice, there seem to be many engineers to whom it is more or less mysterious. One of the simplest methods of attacking this problem and one which has the advantage of giving correct viewpoints throughout is to compare the boiler passes, flues and other parts with a pipe or conduit carrying water under pressure.

Measuring Head by Standpipe or Gage

Assume for this purpose the arrangement shown in Fig. 1. A large vessel is fitted with an overflow, and water is supplied constantly through the nozzle shown. If the overflow is large enough, the height of water will remain constant at the level shown. The pipe leading from the bottom of the vessel will, for the time being, be assumed closed at the right-hand end. Under such conditions, the pipe will stand full of water under a head h. If holes are drilled in the horizontal pipe and fitted with standpipes, as shown, the water will rise in each standpipe to the same height as that in the main vessel.

If the end of the horizontal pipe is opened so that a steady flow of water can occur, the water in the vertical pipes stands at successively lower heights as the open end of the pipe is approached. This is shown in Fig. 2. The explanation, as commonly expressed, is that part of the head is used up in overcoming frictional and similar resistances to flow. It is obvious that dynamic conditions (flow occurring) and static conditions (no flow) are different.

Analyzing the case shown in Fig. 2 more closely, the most obvious difference between it and that shown in Fig. 1 is the fact that the water in the former is moving. As water possessses mass, energy is required to give it motion, and this energy can be measured in terms of a head of water. Thus, in the case of Fig. 2 the required head might be that shown by the height h'. This much of the total head h would be used in the large vessel for imparting velocity to the water. The water flowing out of the large vessel encounters resistance where it enters the pipe, and a part of the remaining head h-h' is lost or used in overcoming this resistance. After the water has entered the pipe, flow is continuously resisted by the friction of the walls and more of the remaining head is used in overcoming this frictional resistance.

Thus, just before entering the horizontal pipe the head remaining is h-h', but by the time the water reaches the first standpipe the head has been reduced to h_1. The amount h_1' has been used to overcome resistance to entrance to the pipe and resistance to flow through the pipe up to the point of location of the standpipe. The head h_2' is used in overcoming the resistance offered by friction in the stretch of pipe between the first and second standpipes.

The heads of water used in the discussion above are merely measures of pressures, and pressure gages might have been used instead of standpipes for reading the loss of head or pressure along the length of the pipe. This arrangement is shown in Fig. 3. If gages 1 and 2 are located at the points previously occupied by the corresponding standpipes, the difference between the gage readings will be equal to h_2', if converted into feet of water.

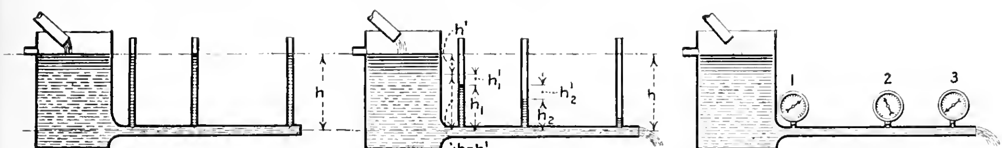


FIG. 1. FIG. 2. FIG. 3.

Illustrating Reduction of Pressure Due to Resistance to Flow

It should be particularly noted that the pressure on the surface of the water in the larger vessel is atmospheric and also that the pressure of the water just as it issues from the end of the horizontal pipe is also atmospheric. That means that the total head h must have been used within the system. Part was used in overcoming resistances, the rest in giving the water velocity; the latter part of the head is represented by the velocity with which the jet of water enters the atmosphere.

If difficulty is experienced in recognizing the fact that the pressure of (or on) the issuing jet is atmospheric, it is only necessary to consider what would happen if it were not. If the pressure of water in the jet were greater than that of the atmosphere, the jet would burst or spread laterally as soon as it issued from the confining walls of the pipe. If the pressure of the water were less than atmospheric, the jet would be compressed by the atmosphere to a smaller diameter than that of the inner surface of the pipe.

Showing Variation in Head Graphically

Referring to Fig. 4, with static conditions (discharge end of pipe closed), the pressure throughout the length of the pipe is the same and equal to that caused by the head h plus that caused by the atmosphere on the liquid. This is shown by the line AB at a height above atmospheric pressure equal to a, which represents a pressure equal to that caused by h feet of water. With dynamic conditions, the case is different. The pressure just inside

*Chief of research department of the Edison Illuminating Co. of Detroit

the entrance to the pipe is shown by the height of A', the distance between A' and A representing the head used in giving the water its velocity and in overcoming resistance to entrance at the inlet. If the pipe is uniform for its length so that the friction loss is the same at all points, the loss of head or pressure will be the same per unit of length at any point along the length and the pressure drop will be as shown by the line $A'B'$. When the end of the pipe is reached, the pressure of the water is equal to that of the atmosphere. This is shown by the location of the point B' on the atmospheric line in Fig. 4.

Pump vs. Fan

For the purpose of getting a case which more nearly parallels the conditions existing in the case of a boiler, the arrangement of apparatus so far considered will be slightly changed. Imagine a vessel connected to a pipe and pump, as shown in Fig. 5. When the pump is not in operation, the water will stand at some height h in the tank and the pipe, and the pressure on the two surfaces of the water will be atmospheric. When the pump is operating, the pipe is filled with water which flows up to the top and into the pump. It is obvious that the water is forced to flow up the pipe by the atmospheric pressure exerted on the surface in the open tank, and if this is true, the pressure within the pipe at the same height must be less than atmospheric. Shown graphically, the case would appear as in Fig. 6. In this figure, the pipe length has been straightened and shown on the horizontal axis as before.

At the point A in Fig. 6, which represents conditions just inside the entrance to the suction pipe, the pressure is equal to that due to atmospheric plus that due to the head h less that lost by conversion to velocity and by resistance to entrance to the pipe. There is then a gradual drop due to friction along the straight part of the pipe to the point B, which represents conditions at the entrance to lower elbow. The loss through the elbow is greater than through the same length of straight pipe, and there is therefore a more rapid drop of pressure from B to C in passing through the elbow. The line representing loss of pressure or head then runs from C to E, the pressure decreasing both because of vertical rise and friction loss. The drop EF represents the loss caused by the upper elbow and by resistances to entry at the pump, so that the pressure which would be shown by a gage connected to a point inside the eye of the pump impeller would be that indicated at F, and obviously lower than atmospheric. In the pump the pressure is raised from that shown at F to that shown at G and then there is a gradual and regular loss of pressure again because of the frictional resistance offered by the discharge pipe.

This case is practically identical with that of a boiler under induced draft, as shown in a simplified way in Fig. 7. The pressure in the ashpit is that of the atmosphere. The air is started in motion and passes through the grate and fuel bed against a certain frictional resistance, so that there is some such drop as that indicated by AB in getting from beneath the grate to the interior of the combustion chamber. Flow from that point to the damper occurs in comparatively large passages offering small frictional resistance, so that the drop from the combustion chamber to the damper is not great. In the region immediately preceding the damper, the gases pass through two right-angles and the drop is therefore more rapid for a given distance traveled than it is in the straight run preceding. This is shown by the increased angularity of the line CD. As shown, the damper is only partly open and this would cause a throttling loss DE. From this point the losses go on as before until the air finally enters the fan wheel with a pressure as shown by F. In passing through the fan, the pressure is raised to a value above atmospheric as shown by G and the excess above atmospheric is then lost in passing through the stack, so that the gases are discharged from the open end of the stack at atmospheric pressure.

A more complicated case is shown in Fig. 8, for which a horizontal return-tubular boiler with induced draft has been assumed. Capital letters on the graph refer to positions indicated by small letters in the diagram above. Up to the point D, the case is similar to that just discussed. Beyond that point there is a rapid drop due to loss in entering the tubes, a gradual drop due to friction along the length of the tubes and a rapid drop due to losses at the exit from the tubes. This results in giving a pressure such as that shown by E just outside the

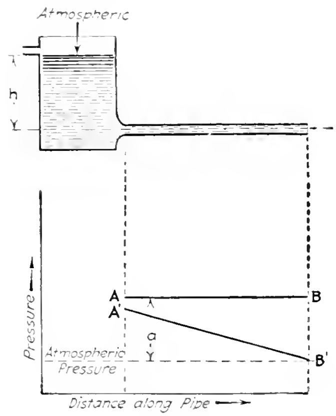


FIG. 4

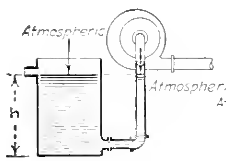


FIG. 5

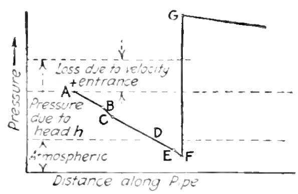


FIG. 6

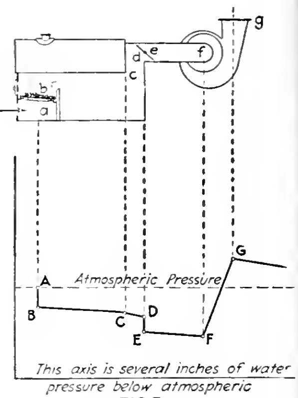


FIG. 7

Showing How the Action of a Centrifugal Pump Is Like That of a Fan tubes in the uptake. From there on the conditions are similar to those previously described.

A more complicated case is illustrated in Fig. 9. A fan draws air from the atmosphere and pumps it into the wind box, raising the pressure from atmospheric to some such value as that shown by A'. The drop through the fuel bed brings the pressure back to atmospheric in the furnace and then the various losses proceed as in previous cases except that the resistance offered by the economizer adds one more complication.

Cases in which induced-draft fans are employed are generally readily understood because it is simple to see that the fan acts as a pump. By lowering the pressure at its own suction it enables the atmosphere to force itself through the boiler and flues toward and into the suction orifice. The fan then raises the pressure of the gases by the amount required to expel them against atmospheric pressure. When a natural-draft stack is substituted for the fan, however, many experience difficulty in appreciating the fact that conditions are not really altered.

mospheric pressure. The weight in pounds supported on a surface one square inch in extent is the pressure in pounds per square inch. The pressure of the atmosphere at a height of several hundred feet above the surface of the earth is therefore less than the pressure of the atmosphere at the earth's surface.

The second fact above stated is easily appreciated by taking the following point of view. Imagine a given weight of gas to occupy a certain volume, say one cubic foot at a certain temperature and pressure. If this gas is heated and allowed to expand so as to maintain a constant pressure, the given weight acquires a larger volume, say one and a fraction cubic feet. Obviously, there is not as great a weight in one cubic foot of space at the higher temperature as there was at the lower temperature; that is, the density, or weight per cubic foot, has decreased during heating.

These principles may now be applied to explain the operation of a stack. Imagine a tube to stand vertical on the surface of the earth, as shown in Fig. 10. The pres-

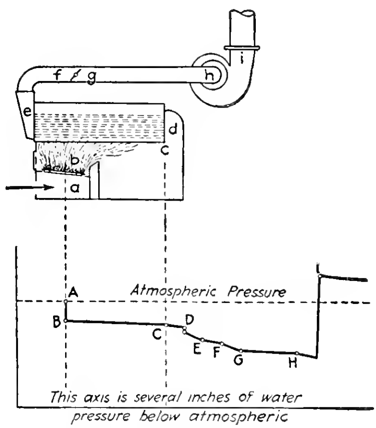


FIG. 8.

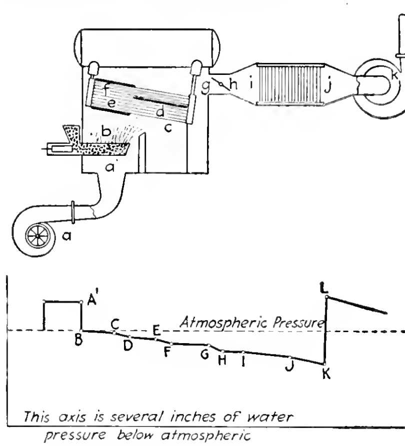


FIG. 9.

DRAFT (PRESSURE) VARIATIONS IN INDUCED- AND FORCED-DRAFT BOILER FURNACES

The stack performs the same functions as a pump in that it lowers the pressure at its suction orifice or base so that air under atmospheric or higher pressure in the ash-pit can force itself through the boiler and flues into the suction orifice. The stack then practically raises the pressure of the gases to such an extent that they can be expelled against the pressure of the atmosphere at its top.

ACTION OF STACK

Two simple facts must be realized to understand the action of a stack: First, the pressure of the atmosphere increases as one passes from a high to a low elevation, and, second, the density or weight per cubic foot of any gas decreases if its temperature is raised while it expands to such an extent that its pressure remains constant.

The first of these facts can be forcibly impressed by regarding the atmosphere as made up of a series of layers like a pile of boards, books or blankets. Obviously, if one could weigh all the layers above a point several hundred feet above the earth's surface, they would weigh less than would all the layers above a point at the earth's surface. The weight thus obtained is what is meant by at-

sure at the height of the top is that caused by the atmosphere above that point; it may be represented by p pounds per square inch. The pressure at the earth's surface, inside or outside of the stack, will be greater and may be represented by P. It will be equal to the sum of the pressure p and the pressure p' due to the weight of air between a point at the height of the stack and a point at the surface of the earth.

If a horizontal chamber be built on the side of the tube near the bottom and be separated from the tube by a diaphragm, as shown in Fig. 11(a), the pressure on opposite sides of the diaphragm will be the same and equal to that of the atmosphere at the height d above the surface of the earth. If now, the air in the tube be heated it will expand, and some of it will leave, so that a smaller weight will remain within the tube. The downward pressure p at the top of the tube will be due to the atmosphere above that point and will obviously be the same at any point in a horizontal plane at that height. The pressure at the center of the diaphragm on the outside will be P as before, as shown in Fig. 11 (b). But the pressure on the tube side of the diaphragm will be P' less than P, because the column of hot air inside the tube weighs less than a column of an equal height of cold air outside of the tube.

If, now, the diaphragm be imagined to be a frictionless and weightless piston, it is obvious that it will move to the right because of the greater pressure on its left-hand side. If the lower end of the tube be imagined to be constructed with an easy bend, the piston would be pushed clear to the top of the tube, because at any lower point the pressure on its lower side would be greater than the pressure on its upper side, as shown in Fig. 12. In this figure P_1' must be less than P_1, because the column of hot air of height a inside the tube weighs less than the column of cold air outside the tube.

A stack or chimney filled with hot air and surrounded with cold air can thus pump the hot air out of itself against the pressure of the atmosphere above. It should be noted in this connection that when the stack is filled with hot gas the pressure within at the base is less than that outside, as shown in connection with Figs. 11(a) and 11(b); that is, the stack "creates a draft." It should also be noted that the pressures outside and inside of the stack are the same at the top, so that the "draft" or "under-pressure" within the stack tapers from a maximum value at the bottom to zero at the top. This is shown diagrammatically in Fig. 13.

It is easy to see that the line representing the pressure within the stack must always lie below (to the right of) the line representing the pressure outside the stack at the same level, from the argument given in connection with Fig. 12. It is also easy to see that it must lie above (to the left of) the line representing atmospheric pressure at the top of the stack, because at any point below the top the pressure inside the stack is equal to the atmospheric pressure above plus that due to the weight of hot air down to the same point.

To convert the model so far considered into an operative stack, it is only necessary to supply a means of continuously heating air as it enters the bottom of the stack, so that the shaft will always be filled with gas at a higher temperature than that outside. This could be done by the use of gas flames playing on the base or by the use of an electrical heater placed within the air at the base. The external cold air would enter at the bottom continuously in an effort to displace the warmer air in the shaft, but as it would be heated as fast as it entered, the process would become nothing more than a gradual sinking of the external atmosphere into the stack and a procession of that same atmosphere up the stack after being heated.

In practice, the air in passing through the fuel causes the latter to burn and liberate heat. Part of this heat is carried in the products of combustion to the base of the stack and serves to maintain the necessary high temperature within the stack. This process is unfortunate in one respect. When the fuel burns, its combustible constituents unite with the oxygen of the air and the weight of gas leaving the fuel bed and traveling up the stack is greater than the weight of air entering by the amount of fuel burned. This means simply that the gases entering the stack would be heavier than the air at the same temperature and they must therefore be heated to a higher temperature than would pure air to give the same "draft" at the base of the stack.

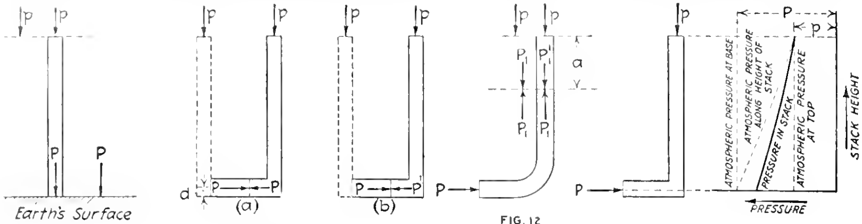


FIG. 10. FIG. 11. FIG. 12 FIG. 13.

ILLUSTRATING WHY A STACK CREATES A DRAFT

STACK AS A PUMP

The stack may now be investigated in connection with a real boiler, considering it a pump, as was done with a blower previously. For this purpose a stoker-fired water-tube boiler supplied with a forced-draft fan has been assumed, as shown in Fig. 14. Capital letters on the graph of pressure variation indicate the same points represented by the corresponding small letters in the diagram. The directions taken by the various parts of the graph should be easily understood from what has preceded.

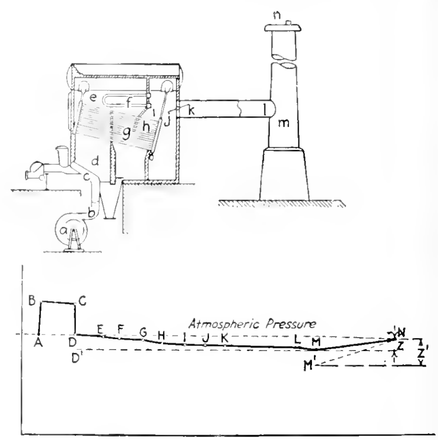


FIG. 14. SHOWING DROP IN PRESSURE IN DIFFERENT PARTS OF BOILER

It is obvious that the drop of pressure from D to M is caused by the various resistances offered to the flow of the gas by the different parts of the boiler and setting. If the same low pressure indicated at M could be maintained while no gas was allowed to flow, there would be no loss of pressure between d and m. The pressure at d would therefore have to be the same as the pressure at m

(neglecting slight differences of elevation) and the graph of pressures between d and m would be a horizontal line as indicated by $D'M$. This is merely another case of the difference between static and dynamic conditions previously discussed; with static conditions there is no loss of head, with dynamic conditions there is such a loss.

But the stack itself is a pipe which carries gases when in operation, and there must be a similar loss of head in it under such conditions. Were one to calculate the pressure at the base of the stack shown in Fig. 14 for a given set of conditions by using the method indicated in connection with Fig. 11, a value such as indicated by the point M', lower than M, would be obtained. The difference between atmospheric pressure and that indicated by M'—that is, the pressure difference Z'—is called the theoretical draft and is the pressure difference which would be available under static conditions. Under conditions of flow, however, part of this pressure difference or driving force is used in the stack, so that only the smaller pressure difference Z remains available for overcoming the resistances in the boiler and flues.

Gas Velocity and Resistance

The frictional and similar losses in such things as pipes, flues and stacks increase approximately with the second power of the velocity of flow through them. Since greater quantities of gas flow through a stack when the boiler is operated at high ratings than when operated at low ratings, the loss in the stack must increase rapidly as the load increases. If no modifying conditions entered the problem, it would be necessary to have such a high stack to get the necessary available or useful draft at high boiler ratings that the damper would have to be nearly closed at moderate ratings. Fortunately, this is not necessary to any such extent as might at first seem probable.

The temperature of the products of combustion rises rapidly with increasing load, so that the density of the column of gases in the stack rapidly decreases. There is, therefore, a tendency toward increased draft as the load increases. This is partly balanced by the fact that increasing temperature and decreasing density mean increasing volume and therefore increasing velocity and loss, but the improvement is sufficient, within ordinary ranges, to more than balance the increased loss.

Again, with a properly operated furnace the excess air used to insure good combustion can often be decreased as the load increases up to a high rating, and this results in the evolution of smaller weight of gas per pound of fuel as the load increases. This would naturally tend to cause a decrease of stack velocity and consequently an improvement in draft.

It is true that in most installations it is necessary to operate with partly closed dampers at light loads and to open the dampers as the load increases. This is not a necessary property of such apparatus, as it is possible to so design the various parts that the available draft is practically self-regulating, and this has been done in several cases.

Wire-Drawn Saturated Steam becomes more or less superheated. Therefore, the apparent loss indicated by the loss of pressure is partly compensated for and the extra pipe friction is the greatest loss. This loss, in turn, is offset to some extent by the fact that the coefficient of friction of superheated is less than that of saturated steam.

Safety in Refrigerating Plants

The special hazards of refrigerating plants have recently received well-deserved discussion in the columns of the technical press, and among those doing good work in this direction is a recent number of the *Travelers Standard*. As every new industry develops, unforeseen causes of accident become apparent, and while the engineer in charge of refrigerating machinery is exposed in such plants to the ordinary dangers of power-station operation, he is also subjected to hazards which need to be specially emphasized on account of their inherent relation to this specialized branch of mechanical service. The growth of the refrigerating industry, employing high-pressure gases with the attendant risk of explosions and other accidents, is attracting the attention of municipal authorities to such an extent that regulations for installing and operating these plants have been drawn up and put into effect in many localities. Experience will, in all probability, show that most of these will have to be revised, and they are likely to have a history paralleling steam-boiler regulations.

As in almost every other industry, the majority of accidents are avoidable. Leaks in gaskets, through cracks in pipes or other defective parts of equipment under pressure, are fertile causes of trouble. Loss of ammonia is often the result of only small leaks, but where large quantities of ammonia escape explosion may result from the mixture of ammonia, hydrogen, oil vapor and other volatile impurities, particularly where open flames are present. Incandescent instead of arc lamps and self-closing doors between the boiler house and rooms where leaks are liable to occur are important safeguards. Provision by which the ammonia supply may be shut off quickly from any one of three or four widely separated points is also a valuable means of protection. In case of a heavy leak the availability of oxygen helmets at convenient places will facilitate temporary repairs and perhaps enable a complete shutdown to be prevented.

Too much care cannot be taken to maintain all valves in operating condition. Many valves in a refrigerating plant are seldom used, and unless tested with reasonable frequency tend to rust in the stuffing-box gland and on the threads of the packing nut. Piston rings in compressors have given less trouble since the snap ring has been used. While the installation of a relief valve in a bypass or in a connection between the discharge side of the compressor in front of the stop valve and the suction side of the compressor in front of the suction stop valve will give protection against excessive pressure in the system, objections against this practice have been voiced, and it is hoped that the investigations into this phase of refrigeration safety now being conducted will result in recommendations applicable without apprehension.

In compressing air the engineer should not use a machine that has recently been used to compress ammonia, and in opening gage-cocks it is safer to stand at the side rather than at the front of the glass. Such precautions as standing at the side rather than the front of compressor cylinders and refraining from calking pipes or tightening nuts and fittings under pressure are generally understood but often disregarded. Valve breakage is the most frequent cause of compressor accidents and is due principally to unnecessary wear, improper cushioning or to deterioration of the metal.

Care in testing initial installations of refrigerating machinery is vitally important. Even though the equipment be tested at the factory and found satisfactory, a further test after assembly should be considered essential. It is customary to lubricate compressor-cylinder walls with oil before starting a test, and more or less oil is forced into the piping by the compressor, with resultant pocketing, heating, vaporization and sometimes an explosion if the temperature rise is extreme. Lubricating oil with a low chill point is desirable for regular use, but a high flash point is more important on account of the increased safety of the latter. Gradual starting followed by cooling of the compressor is a safer practice in testing than immediate operation from stand-still to normal or excessive pressure. The use of butt-welded pipes or of unsupported pipes is considered by many to be undesirable in refrigerating plants.

Water-Tank Controlling Device

The device illustrated herewith is designed to stop a pump when the tank is filled and to start it when the level of the water has fallen to a predetermined point.

The apparatus, Fig. 1, consists of a brass pipe, its length being the distance between high level and low level of the water in the tank. The upper end of this pipe is supplied with a strainer, and a valve and copper float are attached to the lower end. Near the lower end a fitting is provided to which an air reservoir is attached.

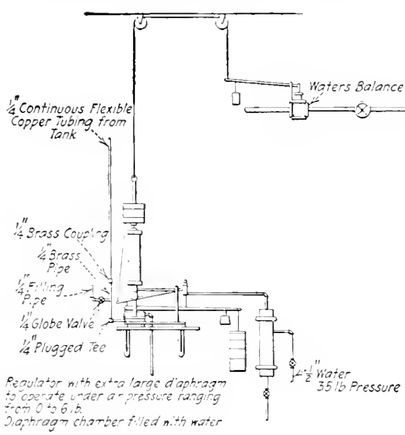


FIG. 2. REGULATOR CONNECTIONS

From the top of this reservoir a pipe is carried to the top of the tank and thence by a flexible copper tube to a damper regulator located near the supply pump. The damper regulator is used to actuate a balanced valve or other device for starting and stopping the supply pump.

The mechanism operates as follows: The water rising in the tank to the top of the pipe overflows into it and compresses the air in the air reservoir. The pressure due to the height of the water in the pipe is transferred through the flexible copper tube to the damper regulator, and it actuates the pump-controlling mechanism and stops the pump. This pressure is held constant until the water in the tank falls to the bottom of the pipe, when the float valve opens and allows the water to escape, relieving the air pressure; and the damper regulator acting in the usual manner actuates the controlling mechanism and starts the pump.

This apparatus has been in operation for four years

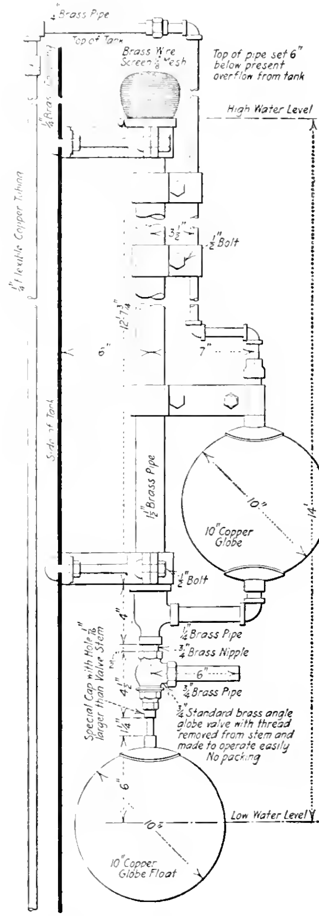


FIG. 1. CONTROLLING APPARATUS IN DETAIL

or more and has proved reliable and satisfactory. It was designed and installed by the Samuel M. Green Co., Springfield, Mass.

Reducing Valves which are too large for the amount of steam they are to pass are usually unsatisfactory. Either they will open and close continually and chatter violently, or will stand in a position nearly closed and become steam cut and leaky. It is more satisfactory to use two small valves in parallel, one set slightly heavier than the other, so that one will supply steam up to its maximum capacity before the other opens. Another way is to use one reducing valve equal to about one-half the maximum demand, and a bypass of about the same capacity with a hand-operated valve in it so that when the reducing valve reaches its capacity the bypass valve may be opened wide and the reducing valve will close down and simply make up the shortage. This, of course, requires that an attendant shall observe the pressure gage occasionally.

Editorials

The Unusual in Engineering Education

Operating engineers of New York City and vicinity have recently had presented to them something worthy of comment in the way of engineering education, yet the character of the presentation is centuries old and the subject is indeed not new, though the proper recognition of its importance is growing.

The subject is the central station versus the isolated plant. The presentation is in the form of a three-act play, with real engineering characters, telephones, charts, records, instruments—everything, in fact, necessary in depicting the problem of how an engineer, his employers and the central station proceed with the business of settling the question of continued isolated-plant service or service purchased from the street.

The curtain goes up on the usual scene of a plant where the engineer has tried to induce the management to buy the instruments and equipment essential to obtaining and recording the data required to show the performance of the plant, but where his requisitions have been repeatedly turned down. The central-station representative, being eminently fair, desires not to take his legitimate advantage of conditions and suggests a call after the plant has operated six months longer to determine what it can do. The issue is forced and the long-lacking equipment is obtained and, which is rather important, *used*.

The end of the trial period sees a proud engineer, an enthusiastic management, and a solicitor who, though regretting his inability to "land" the plant, is frank in his admiration of engineer and management. His little discourse at the close of the last conference should be learned "by heart" by every engineer and vigorously applied. It is the same old sermon about most isolated-plant failures being primarily the fault of the engineer, but a sermon whose value will decrease only as the need of preaching it diminishes.

All things considered, the members of Brooklyn, Number Eight, National Association of Stationary Engineers who conceived and who executed the idea deserve commendation. There are some points which bring forth criticism. But then, these men are not playwrights nor trained actors, neither have they rehearsed or produced sufficiently. Time will supply these needs.

To avoid impressions that impair the value of the play, the members must be extremely careful not to seem to advertise any particular make of apparatus. Some of the slides shown during the consulting engineer's talk to the superintendent do this too plainly, to the dissatisfaction of many in the audience. But that this effect is not intentional is evidenced by the fact that parts of the "lines" which were similarly objectionable have been changed, while the slides are undergoing like treatment. When these features, which excite the critic, are removed, the "company" will, in theatrical parlance, "put it over great."

As a suggestion, we would add that when time permits the evening might be made more valuable by following the play with discussion of the question by audience and players.

Merging Hydro-Electric Interests

The reported plan for merging control and ownership of large hydro-electric and utility corporations in Montana, Washington, Idaho, Utah and Colorado will be urged as an additional reason for the speedy enactment of water-power legislation, when Congress reassembles next winter.

Secretary Lane of the Interior Department, father of the fifty-year leasing plan for the disposal of water-power sites in the public domain which was passed by the House and allowed to die in Senate committee in the last Congress, announced a few days ago that the leasing bill would be reintroduced immediately upon the meeting of Congress in December and expressed the hope that it would pass without further delay. Although the Secretary did not say so, it is understood that the water-power bill will be a part of the Administration's legislative program next winter and that the influence of the President will be used to force the measure to passage.

Consolidations and mergers said to be planned in the states mentioned will place under single corporate control about fifty per cent. of the developed water powers in the Western states. In commenting upon this situation, Secretary Lane said:

"Such a consolidation, involving widely separated power plants, inter- and intrastate transmission lines and Federal questions beyond the scope of state utility commissions, emphasizes the necessity for Federal control and regulation in the interest of the public."

It is reported that the Electric Bond & Share Co., of New York, is the parent of the gigantic merger program. The power which would come under the control of the New York company by the consummation of the several mergers that have been made this year or are in contemplation would aggregate more than 565,000 developed horsepower and about 150,000 horsepower of undeveloped hydro-electric energy.

The Bond & Share Co.'s interest in the merger and control of these Western power sites and plants is represented, according to reports, by a holding company recently formed and known as the National Securities Co. The Bond & Share Co., in turn, is known as a subsidiary of the General Electric Co., and the completion of the merger program will give the General Electric practical control of the hydro-electric field west of Denver.

In the taking over of the Utah Light & Railway Co. by the Utah Power & Light Co. some time ago, all the important water-power plants in Utah were consolidated into a single-headed system. The merger of plants in

Oregon and Idaho now proposed, will similarly unite the hydro-electric plants in these states, heretofore owned by the following companies:

DEVELOPED WATER POWER

	Horsepower
Idaho-Oregon Light & Power Co.	7000
Idaho Railway, Light & Power Co.	14,000
Idaho Power & Light Co.	7500
Great Shoshone & Twin Falls Water Power Co.	9000
Thousand Springs Power Co.	3000
Southern Idaho Water Power Co.	5000

These interests have heretofore been regarded as quite divergent. The Idaho Railway, Light & Power Co., which operates the traction system in Boise, has for some time been seeking a consolidation with the Idaho-Oregon Light & Power Co., which does a commercial business in Boise. The Idaho-Oregon Co. was formerly controlled by the Mainlands, of Oshkosh, Wis., but has been in the hands of a receiver for some time, the receivership being forced primarily by the reduction of power prices from fifteen to nine cents as a result of the entrance into that city of the Idaho Light & Power Co., in competition with the older concern. The Idaho Light & Power Co. has been trying to get into the Twin Falls and Pocatello fields also, and there has been litigation because of the action of the Idaho Public Utilities Commission in permitting the company a "certificate of public necessity" to enter Twin Falls and not Pocatello.

In the Utah merger, by which the water powers of the state came under single control, there were involved plants aggregating 112,850 horsepower of developed energy. The projected acquisition of the Washington Water Power Co. by the same interests will give the General Electric Co. control of the following companies in the Northwest:

DEVELOPED WATER POWER

	Horsepower
Montana Power Co.	184,000
Washington Water Power Co.	156,000
Pacific Power & Light Co.	23,750
Colorado Power Co.	42,250
Utah Power & Light Co.	112,850
Proposed Idaho merger	45,500
Total	564,350

The plan of merger proposes that shares of the older companies shall be exchanged for shares of the new holding company, the National Securities Co., and that all the plants will be operated by a big new company to be organized for this purpose.

Among the power plants involved are those at Oxbow on the Snake River and at Horseshoe Bend on the Payette, owned by the Idaho-Oregon Co. The Idaho Railway, Light & Power Co. owns a power plant at Swan Falls on the Snake River. Other plants included are those at the Shoshone Falls on the Snake River and at American Falls, Idaho. All these power sites were on public land and were the property of the people of the United States until within recent years, and practically all of them passed into private ownership for a nominal consideration and without qualification.

There is no control over water-power companies by state utility commissions in Colorado, Wyoming, Utah or Montana.

Without raising the question of whether the water powers can best be developed by competition or by monopoly, advocates of the Ferris bill urged that the drawing tighter of the lines of private monopoly emphasizes the need for legislation now to protect the public's interests in the power sites still remaining in the public domain.

With half the power of the West under single control, it is urged by Secretary Lane and other advocates of the leasing plan and Federal regulation for power sites in the public domain that the Government should perpetually maintain a controlling hold upon these great natural resources, the value of which is not yet fully apprehended. It is pointed out by these same men that state utility commissions cannot do much in protecting public interests against such a great and powerful monopoly, which would be sufficiently strong to dominate the politics of almost any of the states in which it operates.

A small number of Western senators and congressmen who helped defeat the Ferris bill last winter, urged that a leasing system would retard development, inasmuch as it would discourage investment of capital in water-power enterprises, and that what the West wants is development at any price. In the face of the magnitude of the monopoly that will be created by the mergers now projected, it is not believed that this position can be maintained by this element.

"If the water power sites of the West are allowed to pass into private ownership without restriction," said Secretary Lane, recently, in discussing the matter, "it is apparent that it will be practically impossible to regulate or control monopoly in this important resource or to regulate this product in the interest of the consumer. The possibilities connected with the utilization of the water power of the United States are not at this time realized, nor can anyone predict what changes in the method of development and control will be required by the public interest in the course of fifty or a hundred years from now.

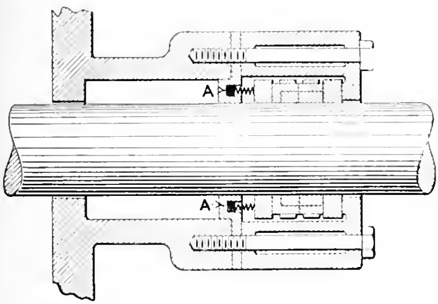
"Only by retaining the fee to these lands and rights in the Federal Government and a measure of control, can the interests of the public, present and future, be properly safeguarded."

Encouraging reports continue to come in showing the favorable attitude of the various states toward the American Society of Mechanical Engineers' Standard Boiler Code. Thomas E. Durban, chairman of the Committee on Uniform Standard Specifications, of the American Boiler Manufacturers' Association and the National Tubular Boiler Makers' Association, has received assurances from J. D. Beck, Industrial Commissioner of Wisconsin, that the State of Wisconsin will "stand by" the recommendations of the committee to the fullest extent and will publish the list of boiler makers who have adopted the Code of the American Society of Mechanical Engineers in the literature of the Commission, in order to encourage the purchase of boilers from such manufacturers. Also an assurance by J. F. Sturgis, superintendent of the Boiler Department of the London Guarantee & Accident Co., Ltd., that all specifications furnished by that company to its assured will conform to the A. S. M. E. Code.

Correspondence

More Spring Tension on Packing

On a 24x48-in. Corliss engine exhausting into a barometric condenser, the vacuum would not go over 22 in. The trouble was located in the metallic piston-rod packing; although it was a good fit on the rod, the tension



Brass Plugs under Springs

was insufficient. Brass plugs the size of the hole and ⅜ in. long were put under the springs at *A* to increase the tension. Now we have no trouble in maintaining a 27-in. vacuum.

Thomas Sheehan.

Williamstown, Mass.

Quarter-Turn Shaft Coupling

In the Jan. 26 issue, page 117, there is an article on a "Quarter-Turn Rod Coupling," which, it is stated, was invented by C. P. Hall, of Chicago. Such an appliance has been in use many years and is known as the "Hobson" patent.

James McClure.

Fletcher, N. C.

So far from the quarter-turn rod coupling being new, I know it to be at least twenty-five years old. A fisherman in a little town in Nebraska, where I lived when a boy, carried such a contrivance around with him in his pocket. It was made of two wooden spools and four wires applied substantially as shown in Power.

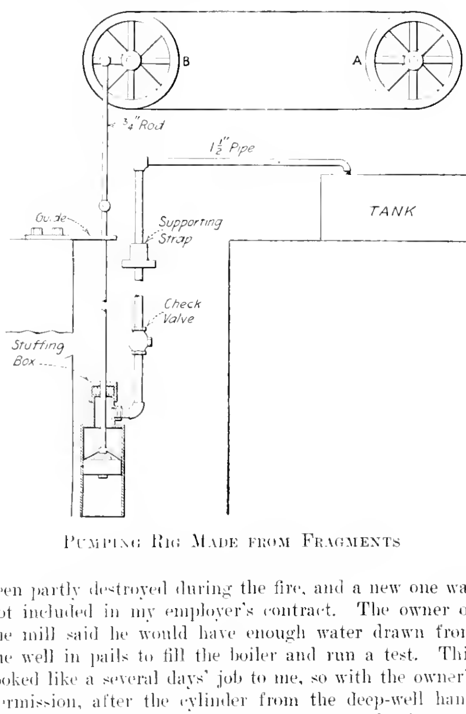
C. O. Sandstrom.

Kansas City, Mo.

[The quarter-turn coupling referred to embraces the idea of the Hobson patent, of which there are at least two kinds. One consists of a number of right-angled rods which move in perforated guide flanges on the ends of shafts and run at right angles, the rods drawing in and out through the flanges as the shafts revolve. A large angle rod serves as a center bearing. Another coupling is made with four angle rods which slide in holes in the shaft coupling. The difference between this coupling and that described in the Jan. 26 issue is that Mr. Hall's coupling consists of six angle rods and the shaft couplings are made longer, so that when the rods are fully extended the end comes at the center of the couplings, and when the rods are at their inner position they come flush with the inner end of the coupling. In the "Hobson" patent, in one coupling the angle rods extend beyond the inner end of the coupling when at their inner position, and in the other design but ⅓ of the shaft coupling has a bearing on the angle rod when extended. In these two respects the Hall coupling is superior to the original patent, as a greater bearing surface is obtained without the necessity of the objectionable protruding angle rods. The principle of the coupling is the same.—Editor.]

Sawmill Engineering

A sawmill was burned down in northern Ontario, fifty miles from a railway, and I was sent out to install a boiler and engine in the new shack called a mill. There was a 55-ft. open well on the property, the water being about 45 ft. from the ground level. The old pumping outfit had



Pumping Rig Made from Fragments

been partly destroyed during the fire, and a new one was not included in my employer's contract. The owner of the mill said he would have enough water drawn from the well in pails to fill the boiler and run a test. This looked like a several days' job to me, so with the owner's permission, after the cylinder from the deep-well hand pump was found, although the bottom cap and valve were missing, I rigged up an outfit as shown.

The bottom of the cylinder extended to within a foot of the bottom of the well, and the pipe was supported by straps placed around it at several places. A shaft extended up to the pump room, on which there was a pulley. Another pulley with a hole drilled in one spoke was put up over the well and connected to the pump as shown. The first tankful was raised by a couple of men pulling on the belt to turn the pulley. The whole thing was put together in about four hours. I have never been back there (for which I am mighty thankful) but I suppose they have a new pump, although that make-shift affair may still be doing its day's work. It was not a noiseless outfit, by long odds.

JAMES E. NOBLE.

Toronto, Ont.

Some Reasons for Different Rates

The comparison of the sale of electricity to that of ice, by C. R. Seed, in the Mar. 16 issue, although meant to justify central-station practice, illustrates, more than anything else, the injustice of the system of rates in most of the principal cities, as well as in the small towns.

To begin with, let us reconsider the example of Jones, the ice man, together with the figures set forth by Mr. Seed.

To harvest ice *A* (for small consumers):

Cost of labor per ton	$1.00
Cost of machinery, house and equipment, per ton	1.50
Total cost per ton of ice	$2.50

To harvest ice *B* (larger consumers):

Cost of labor per ton	$0.85
Cost of machinery, etc.	0.85
Total cost per ton of ice	$1.70

To harvest ice *C* (still larger consumers):

Cost of labor per ton	$0.75
Cost of machinery, etc.	0.60
Total cost per ton of ice	$1.35

To harvest ice *D* (wholesale consumers):

Cost of labor per ton	$0.70
Cost of machinery, etc.	0.45
Total cost per ton of ice	$1.15

Would it not be reasonably fair to all consumers, large and small, if their rates were based upon the average cost of labor, machinery, house and its other equipment? If this were made the basis of rates for all, the total average cost of the ice per ton, leaving out for the present the cost of transportation, would be

$$2.50 + 1.70 + 1.35 + 1.15, \text{ or } 6.70 \div 4 = \$1.675$$

The fairness of this assumption cannot well be disputed. There is no logical reason why the small consumer should be perpetually burdened with the first cost of the icehouse and its equipment. Of course, the cost of transportation will tend to change the rates somewhat, but transporting ice is far different from the transmission of electricity. A given amount of the latter cannot make any more trips in a unit length of time to a few large consumers than it can to several smaller ones. It may be argued that there is an extra outlay for wire in the latter case, but this item in itself is not sufficient excuse for the great difference in the rates to large and small consumers.

Mr. Seed states that the business of the large consumers causes the whole lot to be cheaper. Yes, cheaper for the large consumers. To farther illustrate my point: Suppose that Jones did not cater to the large consumers, but secured several new small customers, which made it necessary to build another story to his icehouse. The cost of ice per ton of lot *A* being $2.50 exclusive of transportation, the cost of lot *B* per ton in this case would be $1.70, which means that the new customers, although not buying any greater quantities than the old ones, are getting their ice for eighty cents less than the original customers, without whom Jones would have had great difficulties in starting in the ice business.

The foregoing does not sound fair, but it is virtually practiced, as Mr. Seed's article proves. If Jones had been a fair-minded business man, instead of having high rates for one set of his customers and low rates for another set, he would lower the rates for the one and raise them for the other until the rates of both were alike; that is, $(2.50 + 1.70) \div 2 = \$2.10$.

Mr. Seed asks, "Which part of the business would Mr. Jones drop?" Let us see. If he drops the small customers *A*, he will transfer the burden of the original cost of the ice plant to the next smallest consumers, or *B*, and will thus raise their rates from $1.70 to $2.50 per ton; he would also have to raise the rates of the consumers *C* and *D*. But he is well aware of the fact that if he juggled with the rates of these large consumers, they would all proceed to install ice and refrigerating machines of their own. He also knows that the small consumers *A* will not install their own refrigerating plants, and that is why Jones goes as far as he likes with these little fellows and why he will not drop that part of his business.

SAMUEL L. ROBINSON.

Providence, R. I.

With no intention of questioning Mr. Seed's entire sincerity in regard to central-station rates, I propose to carry his analogy a little further and present another view of the subject.

Jones cuts 1000 tons of ice at a cost of $2.50 per ton and markets it at a cost of $6.15 per ton, and to make a profit sells at $10 per ton. Smith and Brown, with a new and modern plant, cut 1000 tons of ice at a cost of $1.25 per ton and use it themselves. Jones, seeing a wider field, installs a plant to handle a larger volume of business at a smaller cost per unit of product and proceeds to cut 4000 tons of ice at a cost of $1.15 per ton, and which he markets as follows:

A. Retail 1000 tons, costing $6.15 per ton for delivery, total	$7.30 per ton
B. Retail 1000 tons, costing $4.48 per ton for delivery, total	5.63 per ton
C. Wholesale 1000 tons, costing $1 per ton for delivery, total	2.15 per ton
D. Wholesale 1000 tons, no delivery, to Smith and Brown	1.15 per ton

For the 1000 tons A he charges $8000, or makes a profit of	$700
For the 1000 tons B he charges $6000, or makes a profit of	370
For the 1000 tons C he charges $4000, or makes a profit of	1850
For the 1000 tons D he charges $2000, or makes a profit of	850
Total profits	$3770

Evidently, *B* is the least profitable and *C* the most profitable part of his business, so Jones proceeds to install a new delivery system, so that

A costs $4 a ton for delivery, or a total of	$5.15
B costs $2.50 a ton for delivery, or a total of	3.65
C costs 85c. a ton for delivery, or a total of	2.00
D costs nothing for delivery, or a total of	1.15

But Smith and Brown have now discovered that it is cheaper for them to cut their own ice than to pay $2 per ton for it, and also that some of the class *C* business is attractive and within their reach. Jones, being on his job, proceeds to revise his price list all along the line and then takes for

A. 1000 tons—$7000 (delivery and cutting costs $5150), profit	$1850
B. 1000 tons—$5000 (delivery and cutting costs $3650), profit	1350
C. 1000 tons—$3500 (delivery and cutting costs $2000), profit	1500
D. 1000 tons—$1250 (no delivery and cutting costs $1150), profit	100
Total profits	$4800

and has not only increased his own profit but effectually disposed of any competition by Smith and Brown.

Query: Would Smith and Brown get quite as good rates if it were impossible for them to molest any of the class *C* business?

Would Jones shade the price on class *C* business if Smith and Brown persisted in cutting their own ice, together with a surplus which they offered to class *C* users?

How long would Jones care for Smith and Brown if he did not have the other three classes to produce his revenue?

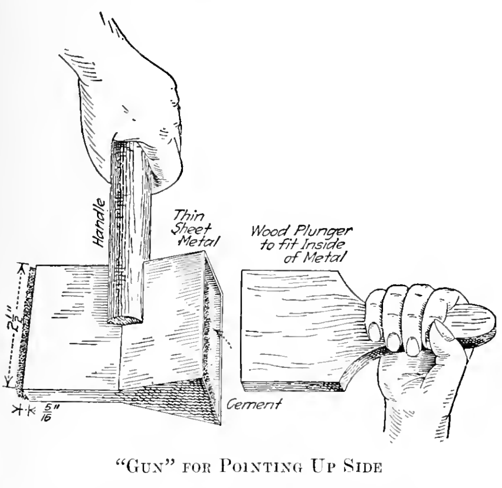
Charles L. Ware.

Maynard, Mass.

Boiler-Room Repairs

Most engineers and firemen are not very skillful in laying brick, but there are times when a few minutes spent in pointing up loose brick with cement or fireclay when the fires are out will develop a good job well done.

Getting fireclay or cement in between brick is not always as easy as it might seem. The illustration shows a



"Gun" for Pointing Up Side

sort of a square squirt gun with which you can fill up the most obstinate crack or hole, and you don't have to be a mason to do it, either.

We always keep on hand a little cement, and whenever a crack shows up and needs attention it takes only a few minutes to fix it, and the job is better than that usually done with the time-honored trowel. Our original model was made from a small tin can and a piece of a barrel stave, which was used until worn out, when we had something suitable made by a tinsmith.

George C. Abbe.

Brooklyn, N. Y.

Increased the Capacity of the Plant

In the plant where I am employed low-grade slack coal was originally burned, because it was considered cheaper at $1.35 per ton than screened lump at $1.85. Later on, an increased load compelled the burning of the more expensive coal. About this time the price of fuel oil dropped until it was considered more economical than coal, when the grates were removed and an oil-burning furnace put in. This was satisfactory until the price of oil again became prohibitive. In the meantime the load had increased until it was useless to replace the original coal-burning furnace and expect to pull the load without additional boilers.

The management, realizing conditions, allowed a self-styled smokeless-furnace company to place its furnace under one boiler with the understanding that it would burn the poorest southeastern Kansas slack without smoke or clinker. This furnace produced more smoke from less coal than any other I have ever seen, and I have not yet learned how to burn coal containing 18 to 22 per cent. ash and 5 to 7 per cent. sulphur content without some clinker. The "patented smokeless furnace" did not eliminate any of the natural ash content of the coal and one was all that was needed.

It was necessary, however, to get back to burning coal immediately, and on account of the low-set boilers stokers could not be put in with any assurance of satisfactory operation. Therefore, it was up to us to devise and put in a hand-fired furnace that would deliver sufficient overload capacity to pull our constantly increasing load and at the same time meet modern economic requirements and compete with the central station.

The original layout consisted of four 250-hp. Heine water-tube boilers set 5 ft. above the floor at the front and 3 ft. 6 in. at the rear and baffled with T-tile which exposed the lower half of the bottom row of tubes to the flame. The boilers were connected to a steel-concrete stack, 8 ft. diameter and 172 ft. high, which gave a draft of approximately 0.9 in. of water at the dampers and eliminated the necessity of using forced draft, provided sufficient air opening and grate surface were supplied.

The grate surface was extended from 42 in. in length to 56 in., using a shaking and dumping grate having 48 per cent. air space instead of 42 per cent. The T-tile was replaced with a box-tile baffle which protects the unburned gases from the comparatively cool tubes during a critical stage of combustion, which is completed by the time the gases have passed through the combustion chamber, provided sufficient air is admitted over the grates. This feature was supplied by using a rather large damper on the fire-door, the liner of which was perforated according to common practice, and breaking up the air prevents it from stratifying through the furnace. The ashpits were lowered 6 in., which permitted lowering the back end of the grates 10 in., giving them about the same pitch as the water tubes, and adding several cubic feet to the combustion space.

A small amount of steam admitted under the grates has a cooling effect on the molten ash and dampens that already on the grates, thereby preventing the formation of large clinkers. This makes it possible to clean the fires by shaking the grates moderately at 1½- to 2-hour intervals. This steam is supplied by a bleeder from separators on the power units, which were formerly trapped into a feed-water heater. This trap, however, was almost constantly discharging, and it was believed that, as the feed-water heater was large enough to bring water to the boiling point, the condensation would be worth more in the ashpits than in the heater.

With this furnace we can develop 75 per cent. overrating, with but little smoke, burning slack averaging 10,000 B.t.u. and containing 18 to 22 per cent. ash and cleaning fires once in twelve hours. Lump coal of about 11,000 B.t.u. and 10 to 12 per cent. ash is cheaper at $1.85 per ton than slack at $1.35, and it is possible to carry a heavier overload. The smoke seldom gets darker than No. 2 Ringelman chart, and CO_2 averages 12½ per cent., with no CO.

B. M. Babcock.

Pittsburg, Kan.

Experience in an Isolated Plant

The following experience of a friend was interesting to me and may be to others:

"Eight return-tubular boilers with hand-fired furnaces furnish steam for a manufacturing plant with a load almost uniform throughout the twenty-four hours. Various steam-saving appliances had been employed in the engine and dynamo room, but we had never received any special consideration out in the boiler room.

"A so-called efficiency expert had given the plant at large a general going-over, but about all the effect we felt was to have the force cut down and the consoling news that our department was wasting more money than other plants of this class. Our superintendent was deeply engrossed in what he termed the 'output' end of the business.

"Our chief engineer was well along in years and not very favorable to 'theoretical steam makers!' One day the superintendent came into the boiler room and with him our engineer and a young man who was a stranger. The young man said little, but nothing escaped his scrutiny; dampers, draft, coal, ashes and our methods of firing. I felt quite curious and a little uneasy. Sure enough, the next day we heard that the steam plant was to be shut down and city current used. Our engineer said he was powerless to help us as the central-station representatives had shown that it would be decidedly advantageous to buy current, and that the superintendent had decided to try it. There were 12 men in our crew, who would have to look for new jobs and we were a gloomy bunch.

"Since being put in charge of the boiler room I had been studying up on flue-gas analysis, draft regulation, etc., with but little encouragement from my chief. As it appeared that we were to lose our jobs anyway, I pleaded with the chief to make a last effort with the office for our plant. With courage born of desperation, I told him the plant deserved to be shut down on account of our wasteful habits, and that our methods were crude, etc. He took me with him to the office, where the superintendent received us cordially. The chief said nothing, but simply turned me over to him. With nothing to lose, I made a straight drive for my point—that with the proper instruments and boiler-room methods our plant could produce power cheaper than the central station. The outcome, without the details, was that arrangements were made for a three months' trial for which we were supplied with a set of gas collectors, differential draft gages on all the boilers, a new damper regulator and provision for forced draft. Team work and head work also played a large part.

"The draft was kept at what was found by experiment to produce the best combustion. Different fuel-bed thicknesses were found to require different draft and different ash-pit pressures to get the CO_2 up to the bonus line. We were determined to make a success of it and did. A bonus system was established among the firemen, the charts were gone over each week and a bonus declared in proportion to the percentage of saving. In this way the firemen were made stockholders in this economy enterprise. At the end of three months, the trial period allotted, every fireman had developed into an efficiency expert.

"We never knew what the city-current fellow's figures were, but at the expiration of our three months' test we knew we had won. We found that the greatest source of waste we had to overcome was excessive draft!"

Edward T. Binns.

Philadelphia, Penn.

Electrically Controlled Damper Regulator

In the Apr. 13 issue, page 517, is a letter from Henry W. Geare on this subject. Mr. Geare seems to assume that by some means or other he determines how much air is required to burn a certain kind and quantity of coal per square foot of grate per hour, and then arranges to pass sufficient air through to burn this coal. Of course he does not say how this is determined, and I believe he would find it difficult to determine. If, however, he did determine it once, it would not be the same the next time he tried to do it, as the quality of the coal would vary.

Further on in his letter is the statement: "It will be found that under that close regulation with natural draft a much more uniform and higher average CO_2 can be maintained, and the efficiency of the boilers increased, with the resulting saving in coal." Much more uniform and higher than what? Further on he states that "the results with natural draft are nearly equal to those obtained by a balanced draft system without the use of blowers;" which I assume is intended to be a general statement and rather broad in application. What is a balanced draft system without the use of blowers? He concludes by saying that "a balanced draft system without the use of blowers increased [and now he refers to a particular case] the cost of power required to operate such systems." What systems?

V. H. Carples.

New York City.

A Prey to the Elements

It is usual to see the bright side of transmission lines illustrated in articles on the subject, but sometimes there is something of value to be derived from their failures.

In the present case all the details of the transmission line were worked out most carefully by government engineers, these were checked up, and then followed the construction, inspection and testing. The towers were put up, tested, and everything done that high-class engineering practice considers desirable. This line ran from the celebrated Roosevelt dam to the neighborhood of the Inspiration Copper Mining Co., in Arizona, and passed over a part of the desert in that vicinity.

The line was in service for some time and no more thought was given to its safety, when suddenly about a year and a half ago there arose in the desert a terrific storm that blew and battled, as storms on the Arizona desert can, and soon showed its disregard for engineering and the government and laid about two miles of

One of the Towers after the Storm

poles or towers to the ground. The condition of one of the towers is seen from the photograph taken shortly after. It will be noted that the tower is clearly buckled and that the rivets and holding parts are still intact. In certain places breaks appear to exist, at first glance, but closer inspection shows that these are the ends of the cross-angles.

A. P. Connor.

Washington, D. C.

Liquid Weigher Improved

A liquid weigher, Fig. 1, failed to operate when the temperature of the feed water became as high as 200 deg. F. The vapors arising from the water evidently formed air pockets in the siphons, causing loss of suction, consequently, the buckets would not drain sufficiently to allow them to turn to the proper position to be refilled.

This difficulty was overcome by making two steel crankshafts $2\frac{1}{2}$ in. diameter, and extending from the center of the weigher through the side walls, and attached to the dashpots on the outside. These crankshafts have a $5\frac{1}{2}$-in. throw and revolve in bronze bearings mounted on the channel beams supporting the bedplate. An arm, or lever, extends from the shaft to the bucket, being fastened between the two short pieces of channels under the bucket, Fig. 2; these channels serve as buffers between the bucket and bedplate. A hole 3 in. diameter was cut in the bottom of the bucket and a special valve, Figs. 3 and 4, made to fit this hole.

After the bucket is filled and tilts the water is turned into the other bucket by the deflector with which the weigher was originally provided, and the valve stem is raised by striking a strip extending across the weigher some distance below the bottom of the buckets. After the water has been emptied into the reservoir the bucket

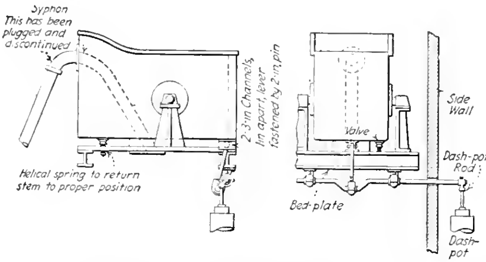


Fig. 1. Section of Weigher Showing the Siphon and Dashpot

returns to its normal position to be refilled, and the valve stem is forced back into its proper position by the helical spring. Should leakage take place through this valve, it can be stopped by increasing the tension of the spring by means of the nuts on the valve stem.

The size of the valve required will, of course, depend upon the time available for one bucket to empty and return to its filling position. The 3-in. valve mentioned allows a bucket containing 485 lb. of water to empty and return to its normal position in from 33 to 37 sec.

Any sort of registering device can be used to count the number of buckets dumped in a given time. An ordinary street-car register can be connected so that each time a bucket is emptied it will be recorded on this register. The amount of water necessary to tilt a bucket can be determined by filling one and allowing it to empty into a barrel mounted on a pair of scales. As the buckets are usually filled through one weir, the total amount of water consumed will be the product of the number of buckets emptied, the pounds of water contained in each bucket, and the number of weirs.

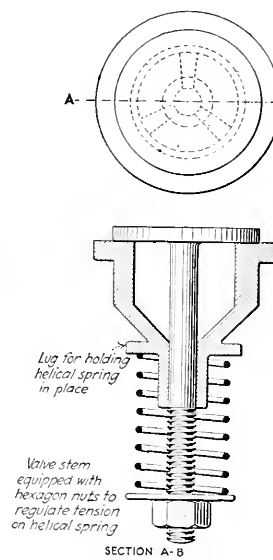


Fig. 2. Section of Valve for Liquid Weigher

After making the above changes the weigher was tested several times before being put into service. The water dumped by the buckets was weighed and the maximum [illegible] differed from the average of a dozen trials [illegible] per cent.

The [illegible] advantage of the weigher (which is a W[illegible] as it is now, over the original one, is that [illegible] no loss of suction on account of the formation of air pockets as there is no siphon effect. The buckets will return to the proper position to be refilled, enabling the operators to keep an accurate record of the total water consumed. Also, the dashspots will give less trouble, as they are no longer submerged.

J. W. LOEF.

Ft. Worth, Tex.

Effects of Throttled Indicator Cock

During a test on an ammonia compressor a number of diagrams were taken whose areas gave a capacity smaller than the machine should have developed. These diagrams were similar to those shown in Fig. 1. The reexpansion line appears, which would indicate a large amount of gas in the cylinder at the end of the stroke.

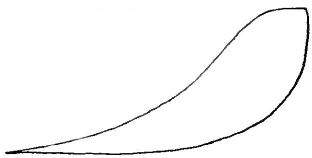


FIG. 1

FIG. 2

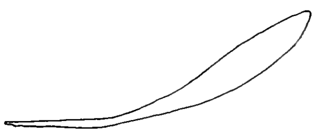


FIG. 3

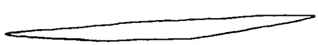


FIG. 4

DIAGRAMS SHOWING EFFECT OF THROTTLED INDICATOR COCK

In this particular machine the compressor cylinders were single-acting and there was every reason to believe that there should have been a constant pressure line throughout the stroke and a diagram similar to Fig. 2 obtained.

Investigation and experiment showed that if a series of diagrams were taken, one after another, with the indicator cock opened a little more each time, diagrams with widely varying areas could be obtained. Further experiment showed that diagrams varying from that shown in Fig. 4 to that shown in Fig. 2, depending on how much the cock was opened, could be taken. The reason for the cock not being fully opened was that in trying to have the least possible amount of ammonia escape, the operator feared to open it. Instead of getting an intake line at constant pressure, the line obtained would indicate a decrease of pressure as the stroke progressed. This was due to the failure of the indicator mechanism to respond because of the reduced opening through the valve.

SIDNEY K. EASTWOOD.

Owego, N. Y.

Starting an Old Dynamo

A moving-picture man in a small Western town got hold of an old direct-current dynamo which he wished to use with a traveling motion-picture show, his plan being to drive the machine from a rear wheel of an automobile.

The dynamo had lain around for many years and it was a question whether it was in operating condition. As the "movie" man had had some trouble with the local light plant's electrician, he did not feel like calling on him for advice, so he called in a fellow who posed as being every kind of a mechanic. The latter turned on the power and got the machine up to speed, but could get no sign of electricity from it. He then proceeded to test out with a storage battery, and finally announced that the fields must have been burned out and that it would be an expensive job to put the machine in running order. The movie man hated to give up the project and, as the lighting company's electrician had the reputation of being an expert, he decided to try to get him. The electrician responded reluctantly and after calling for the battery used by the other fellow, made the same field tests, but refused to make a positive statement about the machine.

That evening a friend of the movie man chanced to overhear the electrician say that it would not take him fifteen minutes to get the dynamo to generate. The next day this was repeated to the movie man, who immediately called for the electrician again and told him what he had heard. The electrician confessed to making the statement and agreed to make the trial. He connected six cells of a dry battery in the field circuit for an instant and then brought the machine up to speed, and when the proper connections were made the dynamo lighted up an incandescent lamp nicely.

The machine refused to generate in the first case because it had lost its residual magnetism and the resistance of the fields was so great that the storage battery could not send enough current through them to be noticed or to make a spark. When the electrician made the test he wet his fingers and made and broke the circuit, so that when the circuit was broken through the wires it was complete through his fingers. There was enough inductive kick to be felt and to show that the field circuit was all right, though no spark could be seen. The six dry cells were sufficient to magnetize the fields enough to give the machine a start.

The movie man was greatly pleased, but still had things to learn about electricity. The next day he brought the picture machine around and proceeded to try it out. The dynamo generated nicely until he switched on the arc, when the voltage suddenly died completely. All attempts to get a sign of an arc across the carbons were futile, so once more the light company's electrician was appealed to. Only one question was asked—"Did you use your rheostat the same as when using the company's power?" The answer was, "No."

He was told to do so, with the result that an arc was had without further trouble.

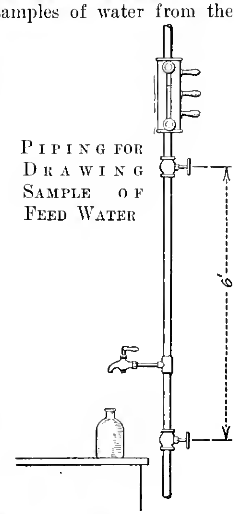
As the dynamo was a plain shunt machine, when the carbons were in contact there was a dead short-circuit across the brushes and nothing to force any current through the field; therefore, the field died and there was no voltage to produce the arc. When the rheostat was in the circuit this resistance prevented the current from flowing through the outside circuit until the voltage was strong enough to build up the field.

G. E. Miles.

Denver, Colo.

Drawing Feed-Water Samples

For taking representative samples of water from the boilers we have found the following to give best results: Each water-column blowoff pipe has an extra valve near the boiler-room floor, and a pet-cock is connected as shown. To obtain a correct sample the bottom valve is opened first, then the one directly beneath the column is opened to blow out the column.



Piping for Drawing Sample of Feed Water

The bottom valve is closed first, then the top one. After the sample contained in the section between the valves has had time to cool, it may be drawn off at the pet-cock into any convenient receptacle.

Edward T. Binns.
Philadelphia, Penn.

Calking Pipe Leaks

In a certain power plant subjected to a working pressure of 100 lb. the lines have given considerable trouble from leakage in the threads. The flanges on the 10-in. main are extra heavy, with the pipe screwed all the way through and peened. In peening these flanges the erector simply beat down the outer edge of the pipe or, rather, riveted it over, but did not peen the full width of the flange. This does not make a good job and prevents the flanges from being taken off, as it tears the threads. These leaks could be stopped temporarily by calking, which was done in the following manner: A calking tool was made with a bit about 3/8 in. wide, then a small groove was cut in the flange with a narrow chisel and this recess calked full of tinfoil. This would stop the leak for a few days, until it worked around the thread to a new place. Some of them were calked all the way around.

The most troublesome leaks were in some short pieces, which were replaced with new ones.

In making the new pieces a full clean thread was cut long enough to screw in the full width of the flange when tight, and to the same taper as the thread in the flange. No "dope" except machine oil to reduce the friction was used in making up the joint, and the pipe was not peened or beaded in the flange. Several nipples were made up in this way and every one gave entire satisfaction without a leak. Some of the other leaking joints were taken down and the entire surface of the joint peened with a heavy ball-peen hammer, but in a few months they were as bad as ever.

The steam line is level and properly drained, with hangers placed not over 10 ft. apart and adjusted to equalize the load on each, but there is some vibration. Steam is not shut off except at long intervals, and there is ample provision for expansion. The principal cause of the trouble is poor workmanship, as those sections, put in properly, give no trouble.

I believe that for ordinary pressure a flange joint should not be peened, and that no "dope" should be used except good oil, because a metal joint is what is wanted, and this cannot be had if the thread is filled up with pipe compound.

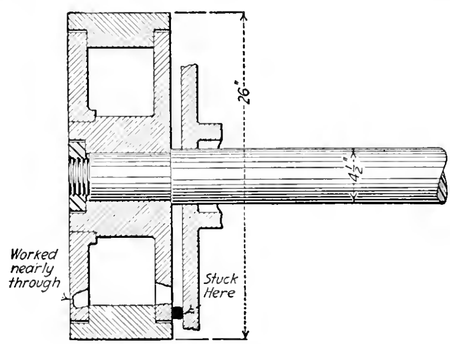
Our experience has demonstrated that a plain screwed joint, properly made up, will hold better than a peened joint.

J. C. Hawkins.

Hyattsville, Md.

Unusual Piston Failure

The piston in our 26x48-in. Corliss engine had a piece of metal of some description left inside when it was plugged up, and after three years of service it worked through the piston on the crank end and was caught between the piston and head, as indicated in the illustration. No damage was done except slightly bending



Piston Wall Worn through

the piston rod. The engine was not shut down for a couple of days, but right after the accident it began pounding badly on the crank end. An indicator diagram was taken, which showed the usual conditions in the head end, but high terminal pressure on the crank end and low compression. It was at first thought that the exhaust-valve stem had twisted, but after studying the diagram it was decided that it would be impossible for the stem to be twisted so that it would lower the compression and raise the terminal pressure. The piston was removed and a hole 1½x1¼ in. was discovered at the bottom of the piston. This was bored out and filled with a 3-in. pipe plug and the diagram was all right.

If any Power reader has had a similar experience I would be pleased to hear from him.

J. W. Dickson.

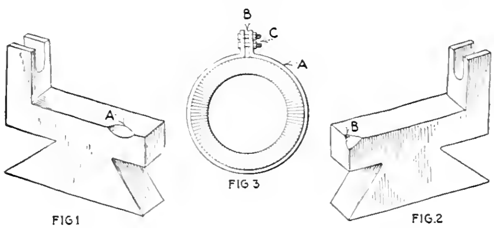
Memphis, Tenn.

Filling Holes in Commutator

The commutator on a 200-kw. generator contained numerous holes which were constantly filling with carbon and copper dust and short-circuiting the segments, with the result that the holes were constantly growing larger. All the well-known methods for filling holes in commutators were tried, but the filling would stay in only a short time, and it did not seem to make any difference what pains were taken to clean the holes before the mixtures were put in; the filling would blow out just the same.

If more time had been available it might have been possible to try something different, but as this was the only source of supply except a storage battery, it could not be shut down for any length of time.

The commutator contained 95 segments, and there was hardly a bar that did not show some kind of hole. They



varied from pin holes to the largest, which covered three-quarters the width of the bar and was ½ in. deep and about ¾ in. long. Some were situated as at *A*, Fig. 1, while others were on the extreme end of the segments, as at *B*, Fig. 2.

While turning the commutator would have helped to a certain extent, as it would have taken out many of the small holes, it was not advisable, as enough could not be turned off to take out all the holes without weakening the commutator; also, it would have been a waste of copper, and there probably would not have been enough carrying capacity left in the segments to take care of the current.

As more load was to be added in a short time, the manager decided to purchase another generator. After wiring the old machine so that it could be run in parallel with the new one, and while waiting for a pulley, it was decided to see what could be done with the commutator. It was thought best to take it apart and put in new mica. Two straps of ¼x1-in. iron were bent around the commutator as at *A*, Fig. 3, a ½-in. space *B* being left at the top. Two bolts *C* were inserted to clamp the strap which, in turn, held the commutator in place after the end-plate had been removed. After taking off the end-plate the bolts were loosened on the straps and the mica between two of the segments was removed and then used as a pattern for cutting the new stock.

Then someone proposed that the holes could be filled with solder, each segment being treated separately, so as not to cause a short-circuit. The question of the commutator becoming hot enough to melt the solder was discussed, but as it had not got hot enough in the past to melt the solder at the leads, little apprehension was felt.

First one, then the other of the straps around the commutator, was moved to the segment that was to be taken out, the opening in the strap coming directly over the segment. After unsoldering the leads the segment was moved to the first strap, and the bolts were taken out to allow the ear of the segment, which was higher than the strap, to pass. The bolts were then put back and tightened, and those of the other strap taken out, so that the segment could be removed.

Where the holes were not too large they were filled with solder, the segment having been heated with a blowtorch. On some of the largest holes the segment was laid down flat and a dam of clay built around the hole. The segment was then heated and the hole tinned, and enough solder melted to fill it. After cooling, it was filed off level so as to conform to the rest of the segment and was put back in the commutator. What is commonly known as "hard solder" was used. About thirty segments were treated.

The new mica was put in where needed, and after the leads were soldered on the segments the end-plate was put on and the straps taken off. The commutator was then turned, as it was out of round and the new mica projected above the bars. It was also the means of removing numerous small holes which were not filled with solder.

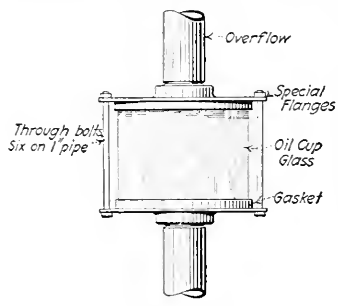
The commutator was still running at the end of five years and had given no trouble.

LEON L. POLLARD.

Fairfield, Maine.

Sight Glass in Overflow Pipe

The overflow water from sealing glands, etc., of high-vacuum apparatus should in all cases be so piped as to be visible to the operator, who can then determine the amount required. He can also detect the presence of undue leakage. A lot of work in one instance was required to locate the cause of a drop in vacuum when the



SIGHT GLASS IN PLACE

overflow was not so piped to a feed-water heater, but if there had been a sight glass, the absence of water, indicating the presence of a leak, could have been noted.

When the apparatus is drained by gravity it is a simple matter to place an open funnel in the line, and where the discharge is under pressure a sight glass can be made as shown in the illustration, using special flanges and a glass from a pressure oil cup with gaskets and through bolts.

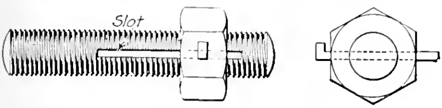
JOHN F. HURST.

Louisville, Ky.

Nut Lock

The nuts on stuffing-box studs sometimes cause quite a lot of annoyance by working off. The illustration shows how I remedied the trouble in a satisfactory manner.

In tightening or loosening the nuts all that is required is to slip the pin out. It is a very easy matter to remove



Slotted Stud for Pin

and replace the pins while the engine is in motion, because it is not necessary to have the hole in the nuts or the slot in the stud so tight that the pin has to be driven in or pulled out with pliers. A flat wire or key is better than a round one. There is no likelihood of the slot closing and allowing the nut to slip over the threads.

J. B. Proctor.

New Orleans, La.

Accident to Pump Plunger and How Repaired

A three-million gallon duplex triple-expansion waterworks pump in a near-by pumping station was a "thorn in the flesh" of the chief engineer ever since it was installed—some eight years previous to the accident. After being in service about three months, it developed a mild pound on one side that was finally traced definitely to the water end, but repeated inspections failed to reveal the cause of the trouble.

The water end, which was of the inserted-barrel type, is shown in the illustration. As there are but few parts in the water end, there seemed to be no reason for the trouble, and several inspections showed that the jam-nut was not loose. The noise became more distinct with time, until the fatal day when the studs *B*, Fig. 1, which held the plunger barrel in place, broke off on one side so that

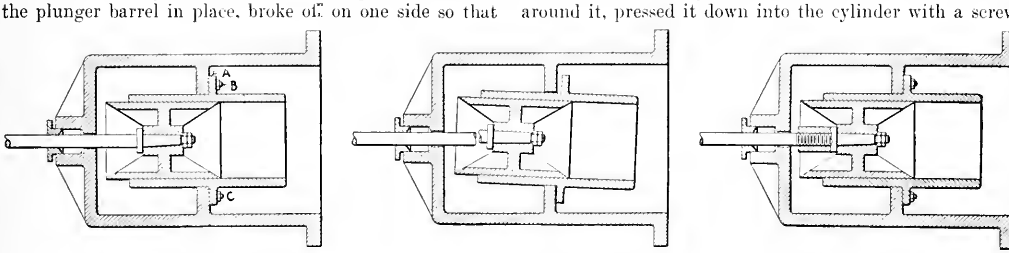


Fig. 1. Original Condition   Fig. 2. Plunger Barrel Displaced and Rod Broken

on the out-stroke the thrust of the rod forced the plunger and barrel off at an angle, as shown (exaggerated) in Fig. 2. This broke the plunger rod off close to the collar.

Upon removing the wreckage the cause of the pound, and also of the accident, was apparent. When the studs *B* were put in at the shop, the threads were not chased down far enough to permit drawing the nuts up against the flange of the plunger barrel, with the exception of three or four which were on one side at *C*. These held the barrel in place for a few months, and then lost motion began to appear at *A*, and grew worse until it had worn in over a quarter of an inch on the flange of the barrel. This continual hammering for several years caused the studs to give way. A new barrel was made and new studs with sufficient thread inserted.

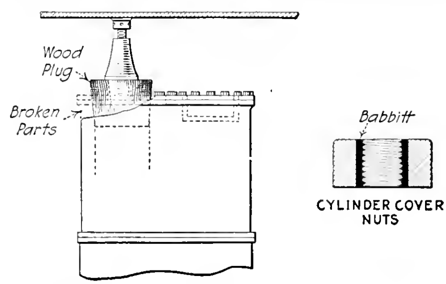
The plunger rod was cut off just inside the collar and threaded. A forging was made which was turned to fit the plunger and looked like a bolt with a large round head bored and threaded to receive the rod, as shown in Fig. 3. A jam-nut was first placed on the rod, as there was enough clearance to accommodate it. The pump now runs better than it did before.

George H. Wallace.

Racine, Wis.

Emergency Cylinder-Head Repair Aboard Ship

On board a Transatlantic steamship we had 8 sets of 8x10-in. fan engines for forced draft. They were located in a hot place over the main boilers. The boilers primed frequently, throwing the water into the steam pipes, and several of the cylinder covers were smashed. In one instance the flange was broken so that a new cover could



Wooden Plug Held in Place with Jackscrew

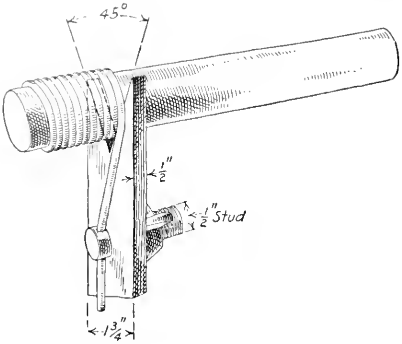
not be bolted on, so we trimmed a block of wood down to fit the bore of the cylinder and, with a sheet of asbestos around it, pressed it down into the cylinder with a screw jack, as shown in the illustration. The engine ran for 10 days, until we reached port, with very little escape of steam.

To prevent the cylinders breaking again we bored out the nuts on the cylinder covers ¼ in. and filled them with babbitt metal, then tapped them out. In case of water in the cylinders it only stripped the soft metal out of the nuts, which were then replaced with new ones and no damage was done We carried a number of these nuts all ready for such emergencies.

New Westminster, B. C. John Dobson.

Spring-Winding Fixture

The illustration shows a spring-winding fixture. Regardless of the diameter of the rod the spring is to be wound on, the tension is adjustable and the strain is taken up by the fixture itself. It is made from a piece of machine steel ½x1¾x14 in. long with a 45-deg. slot in the end, and drilled to receive a ½-in. stud. and a standard



Position of Fixture in Use

½-in. wing-nut. Drill a hole (say ¼ in.) in the stud close up to the head, and the fixture is complete. To wind an open spring the tool is held in the tool post, getting the lead required by the lead screw, the same as for any other purpose. Closed springs are wound with the fixture held in the hand and the wire will give its own lead.

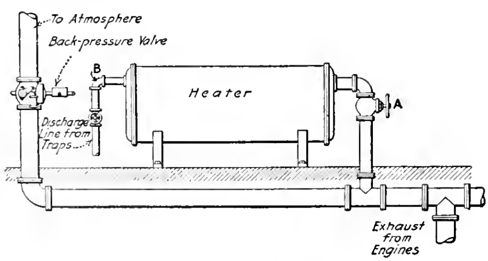
F. L. Young.

Pittsfield, Mass.

Heater Explosions

The illustration shows the arrangement of the exhaust piping, and a heater which was a source of danger that no one had ever noticed until after the head was blown out, resulting in the death of one man.

There were a number of steam traps discharging into



Heater without a Relief Valve

the heater at *B*, and it was customary to partly close valve *A* in case the water became too hot. This valve had an inside screw stem and one could not tell how nearly it was closed except by counting the turns made by the wheel. Just before the accident the feed pumps would not handle the water, so the water tender gave valve *A* a few turns to throttle the exhaust steam. The valve had evidently been left partly closed by the previous watch, so that with the few more turns it was completely closed. As there was then no means of escape for the steam from the traps, an excessive pressure was built up. Some of the traps were out of order and the bypass valves were open, which allowed steam to enter at full boiler pressure. One of the heads was blown out and broken into several pieces. Later, all the heaters were fitted with relief valves.

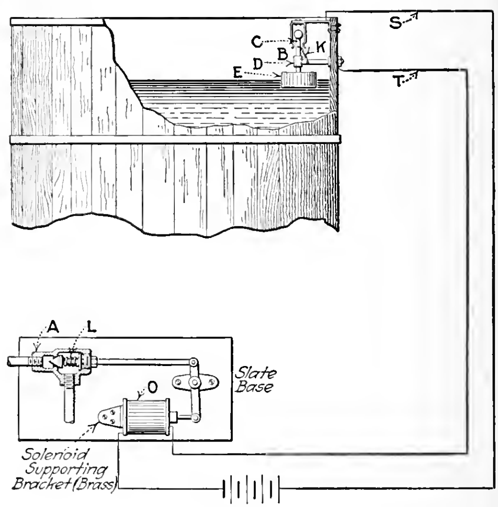
I have seen this same condition in one other plant, which leads me to believe that it may be a common oversight. I think all heaters should be fitted with some form of relief valve.

H. A. Dempsey.

Michigan City, Ind.

Water-Level Control

A mechanism for controlling the water level in tanks is shown. It is adapted to all kinds of water-supply tanks and can be installed at small cost. It consists of a throttle valve *A* operated by the electric solenoid *O*, which is controlled by a float switch *B* in the water tank. This switch consists of a brass spring to which is soldered the wire *S*,



Float and Solenoid Control System

a varnished wood float *E*, in the center of which is fixed a rod *C* with a ball end to make contact with the spring and guided by the arm *D* to which is soldered the wire *T*. Wire *K* is soldered to *C* and *D* to insure a good connection. The solenoid operates the valve through which steam enters to operate the pump.

The operation is as follows: As the water level in the tank lowers, the float *E* descends, closing the electric circuit, throwing the solenoid into operation, opening the steam valve to the water pump; when the pump has raised the water level in the tank to its required height, the float rises, opening the switch releasing the solenoid, and allowing the spring *L* to close the steam valve.

F. B. Hays.

Indianapolis, Ind.

Inquiries of General Interest

Rattling of Exhaust Valves—What causes the rattling noise of the exhaust valves of a noncondensing Corliss engine when running light or when coming to rest after the throttle valve is closed?

R. H.

Under the conditions stated the initial volume and pressure of steam or air in the cylinder may be so small that expansion occurs below atmospheric pressure, and the valves thus become unseated by the pressure of the atmosphere.

Clearance—What is the difference between piston clearance and cylinder clearance?

J. W.

Piston clearance is the distance the piston would have to be moved beyond the end of its stroke to strike the head of the cylinder, and is usually expressed in linear inches, while cylinder clearance is the volume of all the space between the piston at the end of its stroke and the valve face, and is usually expressed as a percentage of the volume displaced by the piston in one stroke.

Obtaining Same Point of Cutoff with Increase of Speed—After increasing the operating speed of an engine, how would the same point of cutoff be obtained for the same load?

C. H. M.

Increasing the speed would require less mean effective pressure, and as with the same point of cutoff there would be the same average pressure per pound of initial, then the increase of speed for the same load and point of cutoff would require a reduction of the initial pressure, obtained either by throttling or by reduction of the boiler pressure.

Determining Brake Power with Indicator—How can the brake horsepower of an engine be determined by use of an indicator and without applying a prony brake?

E. R. M.

The friction of an engine is practically constant for all loads, and as the brake horsepower is the net power developed by the engine, then for all practical purposes the brake power of the engine could be ascertained by determining the highest indicated power it would develop with any kind of load and deducting the power indicated when the engine is doing no other work than overcoming its own friction.

Operation of Automatic Cylinder Lubricator—In ordinary forms of automatic sight-feed cylinder lubricators, how is the pressure of the oil increased so as to force it into the engine steam pipe against the same pressure of steam as that received by the lubricator?

A. A. G.

The condensing chamber of the lubricator is connected by a pipe or passage to the lower part of the oil chamber and, in addition to the steam pressure communicated through the condensing chamber connection, the oil pressure is increased by the pressure due to the head of water of condensation which accumulates in the condensing chamber and its connections.

Allowance for Thickness of Plate—What length of ½-in. boiler plate would be required to form a cylindrical shell 66 in. outside diameter, with butt joint?

G. W. T.

In bending the flat plate into cylindrical form the side that is concaved becomes compressed, the side that is convexed becomes extended and the neutral axis is at the center of the sheet. Therefore, the length of the plate will be equal to a circumference whose diameter would be measured at the center of the thickness of the plate. As this is equal to the outside diameter minus the thickness, and as the diameter measured at the center of the plate would be 66 — ½, or 65½ in., the length of ½-in. plate required for 66 in. outside diameter would be

$$65\tfrac{1}{2} \times 3.1416 = 205.7748, \text{ or about } 205\tfrac{25}{32} \text{ in.}$$

Decrease in Weight from Immersion—When a body is immersed in water, why is its weight decreased by the weight of the volume of water displaced?

J. D. W.

Every part of the surface of the submerged body is submitted to a perpendicular pressure which depends on the depth. If we imagine all these pressures resolved into horizontal and vertical pressures, the horizontal pressures are in equilibrium, while the vertical pressures are unequal and will tend to move the body upward, for the vertical pressures are directly in proportion to the depth. The vertical upward pressures passing through any point in the body will exceed the vertical downward pressure by the weight due to the height of the column of water which is displaced. It follows, therefore, that the total upward pressure will exceed the total downward pressure by the weight of total volume of water which is displaced.

Water Horsepower of Pump—A triplex pump, having plungers 10¼ in. diameter by 24-in. stroke and taking its suction at atmospheric pressure, made 32,200 revolutions during 10 hours' run, pumping against 130 lb. gage pressure per sq.in. What was the average water horsepower and the number of horsepower hours?

F. D.

With three plungers and 32,200 revolutions, during 10 hours' run there would be

$$3 \times \frac{32{,}200}{10 \times 60} = 161 \text{ strokes per minute.}$$

The cross-sectional area of each plunger would be

$$10.25 \times 10.25 \times 0.7854 = 82.516 \text{ sq.in.}$$

and each plunger making 2-ft. stroke and pumping against 130 lb. per sq.in. the water horsepower, without allowance for slippage, would be found by substituting in the usual formula,

$$\text{Hp} = \frac{P \times L \times A \times N}{33{,}000}$$

the values P = 130, L = 2 ft., A = 82.516, N = 161; that is,

$$\text{Hp.} = \frac{130 \times 2 \times 82.516 \times 161}{33{,}000} = 104.67 \text{ hp.}$$

This must be "discounted" by the percentage of slippage, which can only be known by actual test. Allowing 5 per cent. slippage, the average water-horsepower would be

$$104.67 \times (1.00 - 0.05) = 99.436$$

or for the 10 hours' run, 994.36 water-horsepower hours.

Height to Which Water Can Be Forced by Steam Pump—To what height can water be forced by a direct-acting steam pump where the steam piston is 8 in. diameter, the water piston 5 in. diameter and the steam pressure 80 lb. per sq.in.?

F. J. B.

In estimating the height due allowance must be made for back pressure of the exhaust and the loss of total effective pressure of the steam in overcoming friction of moving parts of the pump, difference of atmospheric pressure exerted on the suction and discharge sides of the water piston, and pressure required for overcoming friction of the water, depending on its velocity through the pump, pipes and passages. These losses depend on the design, construction, adjustment and operating conditions. Assuming that 20 per cent. of the steam pressure is employed for overcoming these losses, then 80 per cent. of 80 lb., or 64 lb. per sq.in. of the steam pressure, would be available for operation of the steam piston in overcoming the static pressure due to the height to which the water is forced. As the area of the steam piston is

$$8 \times 8 \times 0.7854 = 50.2656 \text{ sq.in.}$$

the total pressure available for this purpose would be

$$64 \times 50.2656 = 3216.9984 \text{ lb.}$$

and as the area of the water piston is

$$5 \times 5 \times 0.7854 = 19.635 \text{ sq.in.}$$

the static pressure pumped against could be

$$3216.998 \div 19.635 = 163.84 \text{ lb. per sq.in.}$$

At the ordinary temperatures of water, each pound pressure per square inch would be equivalent to the pressure created by a column of water about 2.3 ft. high, and therefore, for the conditions assumed, the pump would force the water to a height of

$$163.84 \times 2.3 = 376.83 \text{ ft.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Fink Lubricating Oil Frauds Still Alive

[The following is taken in its entirety from the pages of the *American Machinist* in the hope that it may come to the attention of some intended victim before he is separated from any real money.—EDITOR.]

Those who remember the exposure long years ago, in 1884 to be exact, by the "American Machinist" of the alleged lubricant put out by Henry (sometimes known as John) Fink are likely to be surprised to learn that he is neither dead nor sleeping, but is still on the job, although his field of endeavor has been removed to the Southwest and the Pacific coast. Nor has his method changed particularly, as was discovered in a recent visit to one of his railroad victims.

Taking care to keep away from the mechanical department, he approached the executive offices with a fine collection of alleged testimonials handsomely bound in morocco covers. These and his winning ways, backed by the apparent evidence, secured the cash.

In this particular instance, the mechanical superintendent was an old reader of the "American Machinist" and also possessed of an excellent memory. As soon as the recipe, which had already been bought and paid for by the executive department, was sent to him, he recognized it as an old friend—or enemy. Making a few extracts from the "American Machinist" of 1884-5, he sent them to the executive offices to show how badly they had been stung. The formula is practically identical with the one purchased and is given below.

Since then he has answered a number of inquiries from railroad and other shops along the Pacific coast as to the value—or rather, the lack of value—of the lubricant, for as soon as Fink secures a victim he immediately turns him into a club to force others into line.

GUARDING AGAINST SIMILAR ATTACKS

For the information of those who do not remember the original exposure and who wish to be thoroughly armed against being victimized, we refer to the bound volumes of the "American Machinist" for 1884-5-6. The original article will be found on page 7 of the Mar. 22, 1884, issue; the others following on page 57, Apr. 12; page 4, May 10; page 7, July 12, and page 8, Dec. 27.

The following year tells of his Canadian exploits, his indictments, and the inability to find him when suits were attempted.

He was written to regarding the compound before the first article appeared, but instead of proving his claims, he answered: "We hereby notify you that any item your paper may publish which will injure us in any way we shall most certainly hold your paper responsible for."

The best-known firms in the country fell victims to his wiles, paying from $100 to $700 for the recipe. After being bitten themselves, they came forward with letters relating their experiences, instead of allowing others to become victims owing to ignorance in the matter. Publicity is the best safeguard against such methods, and we shall be glad to hear from all recent victims, in order that the fame of Fink may precede him and make his efforts unprofitable, if nothing more.

DIRECTIONS FOR MANUFACTURING FINK'S PATENT LUBRICATING OIL MIXTURE

To make 48 or 50 gal. of the mixture, take 15 to 17 lb. best lump lime, 22 oz. pulverized french chalk, 20 oz. carbonate potash, 16 oz. calcine magnesia, and 20 oz. pulverized borax. Put these ingredients into a barrel with the head out and add three or four buckets of hot water. After all are dissolved, fill the barrel with cold water, stir the mixture thoroughly and let it settle for about seven hours. After it is perfectly settled and clear, mix the clear water of the mixture with the oils you now use, in the following proportions.

For engines and cylinders take 17 gal. of lard or cylinder oil, 3 gal. of castor or machine oil, 20 gal. of clear mixture, or 40 gal. clear mixture to give it more body. To lard oil or any animal oil or greases: Light oil, mix one-half oil and one-half clear mixture. Heavy oil, mix one-third oil and two-thirds clear mixture.

To mix any kind of machine or black oil, take 15 gal. of any kind of machine or black oil, 5 gal. of lard or animal oil or cheap grease, 20 gal. of clear mixture, or 40 gal. of clear mixture to give it more body.

These proportions may be varied or changed according to the oils or greases used, the climate, or for various reasons to suit the machinery where oils or greases are used.

Put these ingredients into a barrel with the head out and stir them with a paddle. Do not stir the mixture more than once. Use nothing but clear mixture to mix with oil.

If not strong enough add more ingredients to the barrel of mixture. Rinse the barrel before making a new quantity of mixture. Throw away the settlings in the bottom of the barrel of mixture before making a new quantity. Use the best lump lime and the softest water that can be procured in the manufacture of the mixture.

For paint oil or paint would advise the use of one-half linseed or paint oil and one-half mixture. Then use same as pure oil for painting. For wood oil use same as lard or animal oil in same proportions.

The oils or greases can be used with this mixture to suit any class of machinery or climate, from the very finest and lightest machinery to the heaviest, by using more or less of the mixture. The more of the mixture you add to the oil or grease, the heavier it is.

Perhaps this may sound familiar to some of the victims of long ago.

Recent Court Decisions

Digested by A. L. H. STREET

Child Labor in Alabama—Under a law enacted at the present session of the Alabama legislature, and approved by the governor Feb. 24, 1915, it becomes unlawful to employ any person under 16 years of age in operating or assisting in operating any steam boiler or dangerous machinery.

Use of Streams for Power Purposes—A power company authorized to condemn private property in the conduct of the company's business is not entitled to interfere with the navigable capacity of any of the navigable waters of a state unless such interference is authorized by statute. But it may take the private rights of property of a riparian owner upon complying with the constitutional and statutory provisions relating to the condemnation of private property. (Minnesota Supreme Court, in re Otter Tail Power Co., 151 "Northwestern Reporter," 198.)

Duty to Safeguard Power Machinery—Under the Iowa statute that requires every employer to safeguard dangerous machinery when that is practicable, a stationary engineer cannot be deemed to assume the risk of his employer's failure to safeguard setscrews on revolving shafts connected with pumping machinery. But where an employee relies upon failure to provide guards, he has the burden of establishing the fact of their absence. Then the burden shifts to the employer to show that it was impracticable to safeguard the machinery in the particular instance. (Iowa Supreme Court, Winn vs. Town of Anthon, 150 "Northwestern Reporter" 1036.)

OBITUARY

FRANK W. BALFOUR

Frank W. Balfour, district manager of the Southern California Edison Co., died Apr. 25, at Pomona, Calif. Mr. Balfour came to this country from England in 1886 and was employed in the city engineer's office in Los Angeles. He had been with the Edison company for fifteen years and was its first district manager.

GEORGE L. BAULDRY

George L. Bauldry, chief engineer of the plant of Walter Baker & Co., Dorchester, Mass., died at his home on May 4 after a week's illness with pneumonia. Mr. Bauldry was born 53 years ago at Bourne, Mass., and learned the machinist's trade in New Bedford. Later, he was a member of the Hartford, Conn., fire department. In 1899, after a varied experience, including service with the New York, New Haven & Hartford R.R., he entered the Walter Baker plant as a fireman. By hard study in night school he worked his way upward and in eight years he became chief engineer of the company. In addition to his engineering duties, Mr. Bauldry bore important resposibilities as a citizen. He was a member of the Milton Warrant Committee for two years, and also recently on the committee charged with motorizing the local fire department. A few days before his death he was appointed a member of the board of fire engineers. He was affiliated with various Masonic and engineering organizations and is survived by his widow, a brother and a sister.

A. R. (DICK) FOLEY

"Dick" Foley is dead. When the "Lusitania" received her fatal blow and plunged into the sea off the Irish Coast, Friday, May 7, she took Dick with her.

Mr. Foley, known to all as Dick, probably had as large a circle of friends among engineers and supplymen, both here and abroad, as any other can claim. For about 15 years he was connected with the Home Rubber Co., which deeply feels the loss of one so influential in building up its business. As his friends know, Mr. Foley had made many trips abroad for that company.

Engineering organizations, especially the National Association of Stationary Engineers, have few friends more loyal and helpful than was Mr. Foley. He was a member of the Trenton, N. J., Association, N. A. S. E., and made his home in that city, at 713 Hamilton Ave. The works of the company he so long served is also in that city. He was one of the

A. R. FOLEY

oldest members of the National Supplymen's Association of the N. A. S. E.

Mr. Foley was in the early 50's. He was born in England, came to this country at the age of 21 and settled in Boston. He is survived by a widow, one son and two daughters. We understand that his body will be shipped to Trenton for burial.

PERSONALS

J. E. Woodwell has removed his office to 8 West Fortieth St., New York City, where he will continue the practice of consulting engineering.

H. S. Collette, secretary of J. G. White & Co., Inc., and The J. G. White Engineering Corporation, has resigned from these companies, and expects to reside permanently in California.

R. J. S. Pigott, formerly mechanical construction engineer, Interborough Rapid Transit Co., New York, has been made power engineer for the Remington Arms-Union Metallic Cartridge Co. at Bridgeport, Conn.

Frank H. Williams has resigned his position with Sperry & Barnes Co., New Haven, Conn., to accept an appointment as chief engineer and master mechanic at John Morrell Company's plant at Sioux Falls, South Dakota.

Prof. W. H. Kavanaugh, head of the Experimental Engineering Department, University of Minnesota, has been appointed a member of the International Jury of Award, Department of Machinery, at the Panama Exposition, San Francisco. He is spending the month of May judging exhibits.

Joseph McNeil, who is well known as a former chairman of the Board of Boiler Rules of Massachusetts, and who recently has had charge of the inspection department of the Boston office of the Hartford Steam Boiler Inspection & Insurance Co., is now stationed in the New York office.

O. L. Remington, general manager, and H. P. McColl, engineer, of the Wm. McLean Co., importers, Melbourne, Australia, are visiting the industrial centers of the country. They are making a study of machinery and apparatus devoted to power uses and have established temporary headquarters at the Hotel La Salle, Chicago.

G. L. Fales has become associated with the Raritan Copper Works, Perth Amboy, N. J. Mr. Fales was formerly superintendent of power, Tennessee Copper Co., Copperhill, Tenn. When he left the latter concern, its employees gave him a fine silver service as a mark of their high esteem and good will. The readers of "Power" will remember him as a contributor of several interesting articles on boiler operation.

ENGINEERING AFFAIRS

The National Association of Cotton Manufacturers held its annual meeting at the Copley-Plaza Hotel, Boston, Apr. 28 and 29. The business sessions were devoted to papers and discussion on concrete construction for cotton mills and on the dyestuff situation as affecting the cotton industry.

A. S. M. E. Legislative Work—At a recent meeting of the Council of the American Society of Mechanical Engineers it was decided that the society's representative on the conference committee of the United Engineering Societies be present at the state constitutional convention and coöperate with the representatives of the other engineering societies in any matters bearing upon their mutual interests. It was also moved that a committee of five be appointed to formulate general principles for the guidance of those who may serve the society in a representative capacity, and particularly when dealing with public questions.

Two Awards by the Franklin Institute—The City of Philadelphia, acting on the recommendation of the Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Herbert Alfred Humphrey, of London, Eng., and to Cav. Ing. Alberto Cerasoli, of Rome, Italy, for the Humphrey pump, a device for raising water by the direct application of the explosive energy of a mixture of combustible gas and air. The Edward Longstreth Medal of Merit has been awarded to the late George A. Wheeler for his escalator (an inclined elevator for transporting persons from one level to another). The basic invention was first disclosed in a patent granted to Mr. Wheeler in 1892, and a number of patents were subsequently issued to him for improvements and developments.

NEW PUBLICATIONS

DIRECT-ACTING STEAM PUMPS. By F. F. Nickel. Published by the McGraw-Hill Book Co., Inc., New York, 1915. Size 6x9 in.; 258 pages; 218 illustrations. Price, $3, net.

This book had its basis in a course of lectures delivered by the author before the students of Columbia University. It is not a treatise on pumping machinery in general, but, as the title implies, is confined exclusively to the direct-acting steam pump. Doctor Nickel's experience, extending over thirty years in this line, not only fits him to speak authoritatively on the subject, but has enabled him to weave into the text much first-hand information concerning the development of this type of pump.

In descriptive matter it is not unlike two or three other books on the subject, although the greater number of illustrations render it, perhaps, more complete in this respect. The treatment of such subjects as the duplex valve motion and compounding are original; the chapter on performance factors, distinguishing between different efficiencies, heads, speeds, etc., is particularly instructive. The text is supplemented by a large number of tables covering pipe-line friction, steam forces and duty, and a chapter on the operation and adjustments of direct-acting pumps will be found useful, especially by the operating man.

JOURNAL OF THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

The American Society of Heating and Ventilating Engineers has issued the first number of a quarterly journal. According to the editorial announcement, the new publication is not intended to replace the annual volume of "Proceedings," but rather to present in advance papers to be given before the society. It will also offer a medium for a closer interchange of ideas between members by publishing discussions on the papers, questions asked and answers supplied by the members on any subjects of interest to the organization. The headquarters of the society are at 29 West Thirty-ninth St., New York.

TRADE CATALOGS

Sherwood Mfg. Co., Buffalo, N. Y. Catalog No. 16. Oil pumps, injectors, ejectors, etc. Illustrated, 20 pp., 3½x6 in.

The Deming Co., Salem, Ohio. Catalog J. Power pumps. Illustrated, 190 pp., 7x9 in.

The Jeffrey Mfg. Co., Columbus, Ohio. Bulletin No. 141. Single roll coal crusher. Illustrated, 32 pp., 6x9 in.

The Watson-Stillman Co., 50 Church St., New York. Sectional Catalog No. 92. Hydraulic forcing pumps, etc. Illustrated, 128 pp., 6x9 in.

"Engineering Bulletin No. 10"—The Peterson Power Plant Oil Filter and Accessory Apparatus for Central Oiling Systems is the title of a 32-page catalog recently issued by The Richardson-Phenix Co. of Milwaukee, Wis. This catalog describes the construction and operation of the new Peterson Power Plant Oil Filter, and it is stated that filters of this type having a total capacity of over 1,500,000 gal. are now in operation. Curves are reproduced showing the results of some interesting tests made on oil taken from one of these filters, and a chapter on the necessity of using filters in connection with steam-turbine oiling systems contains much new information. The catalog contains fifty illustrations showing many important installations of Peterson filters and oiling systems. Copy may be had by addressing the company.

BUSINESS ITEMS

John F. Hale, formerly with the Warren-Webster Co. of Camden, N. J., has associated himself with the Consolidated Engineering Co. of Chicago.

To meet the continuously increasing demand for Peerless specialties, the Peerless Rubber Manufacturing Co. has moved into larger quarters at 31 Warren St., New York.

The Jeffrey Manufacturing Co., Columbus, Ohio, has moved its New York Branch from 77 Warren St. to 50 Dey St. George H. Mueller, assistant sales manager of the company, is in charge of this office.

The Richardson-Phenix Co., Milwaukee, Wis., has purchased the patents, good will and manufacturing rights of the Osborne "NoKut" valve and is now carrying a complete line of the various valves in stock. Literature describing the "NoKut" valve is sent on request.

The annual meeting of the stockholders of the Joseph Dixon Crucible Co. was recently held in the company's office in Jersey City. Following are the directors elected: George T. Smith, Robert E. Jennings, George E. Long, E. L. Young, William G. Bumsted, J. H. Schermerhorn, Harry Daily. The officers elected by the Board of Directors are: President, George T. Smith; vice-president, George E. Long; treasurer, J. H. Schermerhorn; secretary, Harry Daily; assistant secretary and assistant treasurer, Albert Norris.

NEW EQUIPMENT

ATLANTIC COAST STATES

The Edison Electric Illuminating Co., of Brockton, Mass., has applied for a permit to build a new substation on Ames St., Brockton. The estimated cost is $3500.

Recent press reports state that the town of Reading, Mass., has decided to extend its municipal electric-light service to Lynnfield, North Reading and Wilmington. The estimated cost of the work is $12,000. Arthur G. Sias, 179 Main St., Reading, is Mgr. and Supt. of the Reading municipal electric-light plant.

The H. B. Ives Co., Artizan St., New Haven, Conn., is having plans prepared for a one-story, brick and steel, 24x44-ft. boiler house, and a 125-ft. stack. R. W. Foote is Arch.

The Eureka Flint & Spar Co., Trenton, N. J., is having plans prepared for the construction of a one-story, 36x85-ft. power house.

The Ebensburg Light, Heat & Power Co., Ebensburg, Penn., is preparing to install one 800-hp. Blake & Knowles open feed-water heater and one Worthington duplex feed pump. E. F. Craver is Gen. Mgr. and Cont. Agt.

The Eastern Pennsylvania Light, Heat & Power Co., Pottsville, Penn., contemplates increasing the output of its plant at Palo Alto, a suburb of Pottsville, by 2000 hp. The estimated cost of the work is $200,000. W. B. Rockwell, Pottsville, is Mgr.

SOUTHERN STATES

Press reports state that the Lynchburg Traction & Light Co., Lynchburg, Va., has appropriated $85,000 for rebuilding its transmission lines. It also contemplates enlarging the Blackwater St. station. J. W. Hancock is Gen. Mgr.

The Parkersburg, Marietta & Interurban R.R. Co. has selected a site in Parkersburg, W. Va., for the location of its new generating station to replace the present power house. The building will be 135x150 ft., and the completed plant is estimated to cost $500,000. Sanderson & Porter, 52 William St., New York, N. Y., is Engr.-in-Charge.

Press reports state that the Baton Rouge Electric Co., Baton Rouge, La., will build a new power plant to cost about $200,000. Donald Stewart is Mgr.

It is reported that the New Orleans Ry. & Light Co., New Orleans, La., will spend about $125,000 in enlarging its power house on Market St.

The Kentucky South-Western Electric Ry., Light & Power Co., Paducah, Ky., will build a new power house in connection with its traction line from Paducah to Murray, Ky. F. M. Smith is Gen. Mgr.

CENTRAL STATES

Bids will be received until noon, May 24, by the Board of Education, City Hall, Cincinnati, Ohio, for the installation of electric-lighting systems in the College Hill School on Maple Ave., College Hill, and the Mt. Airy School, Colerain Pike and Mt. Airy Rd., Cincinnati. C. W. Handman is Business Mgr., Bd. of Education.

The Hilliards Light & Power Co., recently organized at Hilliards, Ohio, with a capital stock of $10,000, will install an electric-light plant to supply the town with electricity. LeRoy Bobyns, T. C. Latham and others are interested.

The Ohio Gas & Electric Co., Lisbon, Ohio, recently organized, plans to establish an electric-light plant in Lisbon. Joseph S. Grayden is interested. Service is now furnished by the New Lisbon Gas Co., which purchases energy from the Youngstown & Ohio River R.R. Co.

(Official)—Bids will be received until noon, May 29, by the Board of Trustees, Miami University, Oxford, Ohio, for alterations and additions to the power plant of the University. The work includes boiler- and engine-room extensions to power building, boiler, feed-water heater, vacuum heating pumps, boiler-feed pumps, power equipment changes and additions. W. L. Tobey, Hamilton, Ohio, is Chn. of Bldg. Com. of Bd. of Trustees. Walter G. Franz, Union Trust Bldg., Cincinnati, is Consult. Engr.

The City Council, Painesville, Ohio, has rejected the terms of the Cleveland, Painesville & Eastern R.R. Co., Willoughby, Ohio, to furnish electricity to the city of Painesville, and has authorized an issue of $35,000 in bonds, the proceeds of which will be used to make improvements and buy new equipment for the municipal electric-light plant.

The City Engineer, Ann Arbor, Mich., has submitted tentative plans to the City Council for the installation of a municipal power plant for lighting the streets and public buildings of the city. The estimated cost is $55,585. Manly Osgood is City Engr.

It is reported that the town of Elizabeth, Ill., is considering the establishment of an electric-lighting system. It is stated that the sum of $8000 has already been subscribed for the purpose.

WEST OF THE MISSISSIPPI

It is reported that a company is being organized to install and operate an electric-lighting system in Ute, Iowa. The estimated cost is $10,000.

The City Council of Hays, Kan., is considering the establishment of a municipal electric-light plant. The estimated cost is $27,000.

Bids are being received by the village of Ceresco, Neb., for the installation of an electric-light plant to cost about $5000. G. Johnson is Village Clk. Grant & Fulton, Lincoln, is Engr.

Bids will be received until May 17 by the Village Clerk of Morrill, Neb., for the installation of a municipal electric-lighting system for the village.

A special election will be held in Tekamah, Neb., on May 18 to vote on the question of issuing $15,000 in bonds for the purpose of establishing an electric-light and power plant. M. S. McGrew is City Clk.

At an election held Apr. 26, the citizens of Victoria, Tex., voted in favor of issuing $40,000 in bonds for the purpose of installing a municipal electric-light plant.

It is reported that the Texas Power & Light Co., Dallas, Tex., has purchased the local electric-light plant at Windom, Tex., and will improve the property. F. R. Slater, Dallas, is Gen. Mgr. of the Texas Power & Light Co.

Bids will be received until May 24 by the City of Montrose, Colo., for the construction of a municipal electric-light plant. It will cost about $6000. E. T. Archer & Co., New England Bldg., Kansas City, Mo., is Engr.-in-Charge.

The Mt. Konocti Light & Power Co., Lakeport, Calif., plans extensions and improvements to its plant to cost about $9000.

The city of Tehachapi, Calif., has voted to issue $8000 in bonds, the proceeds of which will be used for the installation of a municipal electric-light plant.

CANADA

It is reported that the Toronto Electric Commission, Toronto, Ont., will build a new substation at Carlaw Ave. and Gerrard St., at an estimated cost of $65,000.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies** (Labor Bureaus), **Business Op portunities**, **Wanted** (Agents and Salesmen—Contract Work), **Miscellaneous** (Educational—Books), **For Sale**, 5 cents a word, minimum charge, $1.00 an insertion.

Count three words for keyed address care of New York; four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A.M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. P

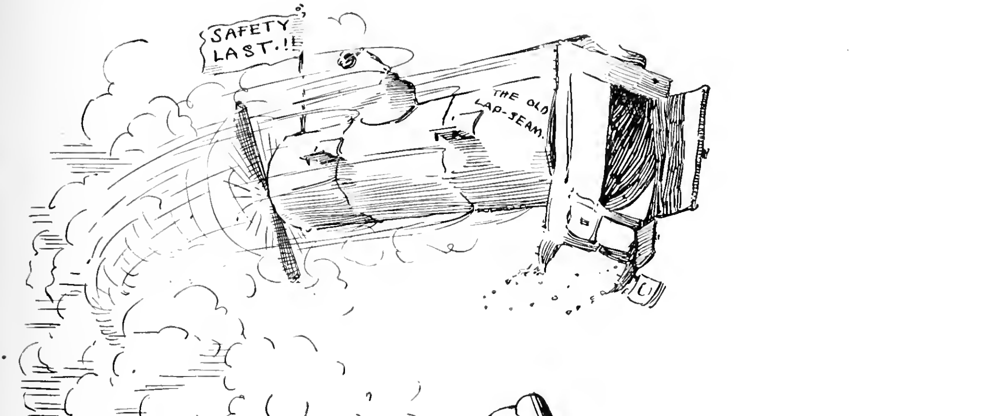
POSITIONS OPEN

CHIEF ENGINEER wanted, one familiar with turbo-generators and Harrisburg engines, D.C. and A.C. power, also must have experience and know good boiler practice; must be able to do necessary repair work and make boiler tests; location, mining town 75 miles from Pittsburgh; salary $110 per month to start; married man preferred. P. 506, Power.

POWER

Vol. 41 — NEW YORK, MAY 25, 1915 — No. 21

How to Bring Down the Game



In the engineer's warfare against the enemies of safety one of the most effective weapons is legislation

(Suggested by George B. Longstreet, Somerville, Mass.)

Harrisburg, Ill., Railway and Power Plant

By Thomas Wilson

SYNOPSIS—A 2000-kw. condensing turbine plant supplying current for an interurban line, for a number of mines and for lighting. A softener and purifier converts hard, muddy and corrosive water into excellent boiler feed at a cost of 1c. per 1000 gal.

On the middle fork of the Saline River (more commonly known as the Big Muddy), two miles from Harrisburg, Ill., the Southern Illinois Railway & Power Co. built its power plant. It has been in operation more than a year, supplying current at 1200 volts to a single-track interurban line running from Eldorado to Carrier Mills, a distance of 16 miles. The intervening stations are Wasson, Muddy, Harrisburg, Dorrisville and Ledford. The cars are run on hourly schedules, and in the morning and evening hours extra service is given to convey the miners to and from their work. Arrangements have been made with the Illinois Central railroad for interline freight service twice a day, and the coal for the plant is hauled over the company's line.

Three-phase 60-cycle current is generated at 2300 volts, and by motor-generator sets this is transformed into 1200-volt direct current for the railway. Current for power and lighting is stepped up to 33,000 volts through

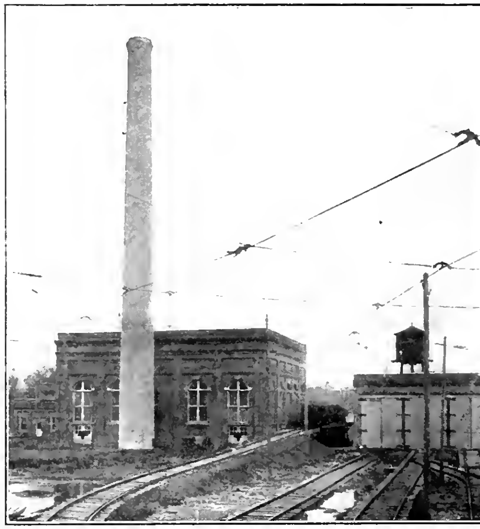


Fig. 1. Harrisburg Plant of Southern Illinois Ry. & Power Co.

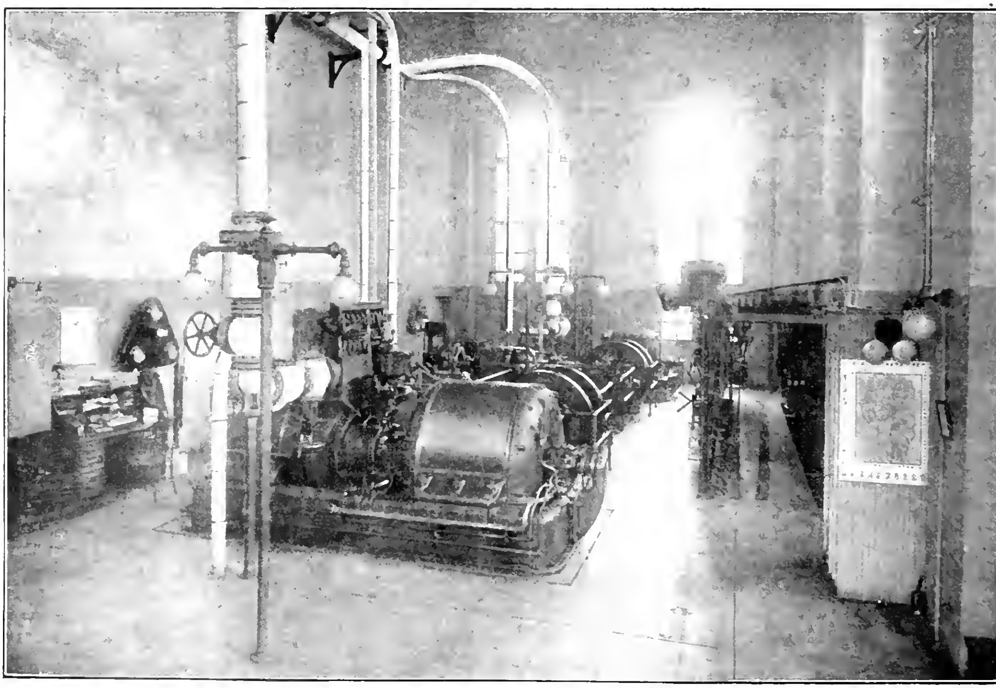


Fig. 2. View in Turbine Room

two banks of three single-phase water-cooled transformers connected in closed delta. At the receiving end it is stepped down to 2300 volts. The Wasson mines, which are electrically equipped, take service. They require direct current at 250 volts for cutting, hauling, etc., and this is obtained through a motor-generator set. Through

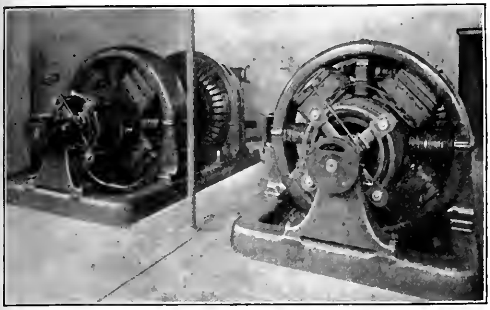


Fig. 3. Motor-Generators Supplying Railway Load

three-phase, 60-cycle, 2300-volt generators at 3600 r.p.m. Condensers are of the surface type, each containing 3600 sq.ft. of surface, or 3.6 sq.ft. per kilowatt of generator rating, and served by a reciprocating dry-vacuum pump, a motor-driven centrifugal pump and a steam-condensate pump. Each circulating pump has a capacity of 3000 gal. per min. The suction of each connects to a 20-in. intake running west from the plant to a crib in the storage reservoir. The latter circles to form a U, so that the discharge from the condensers is received south of the plant at a distance of about one-quarter mile from the inlet. Spray nozzles arranged in clusters of five help to cool the water, and in any event a considerable period of time elapses before the water from the condensers gets back to the intake. The total lift for the pumps is 8 ft. The condensate is pumped to a 1600-hp. open heater, where its temperature is raised for boiler feeding.

It is evident that one generating unit will carry the load, operating at a small overload at the peaks and at a load factor averaging about 40 per cent. the remainder of the time.

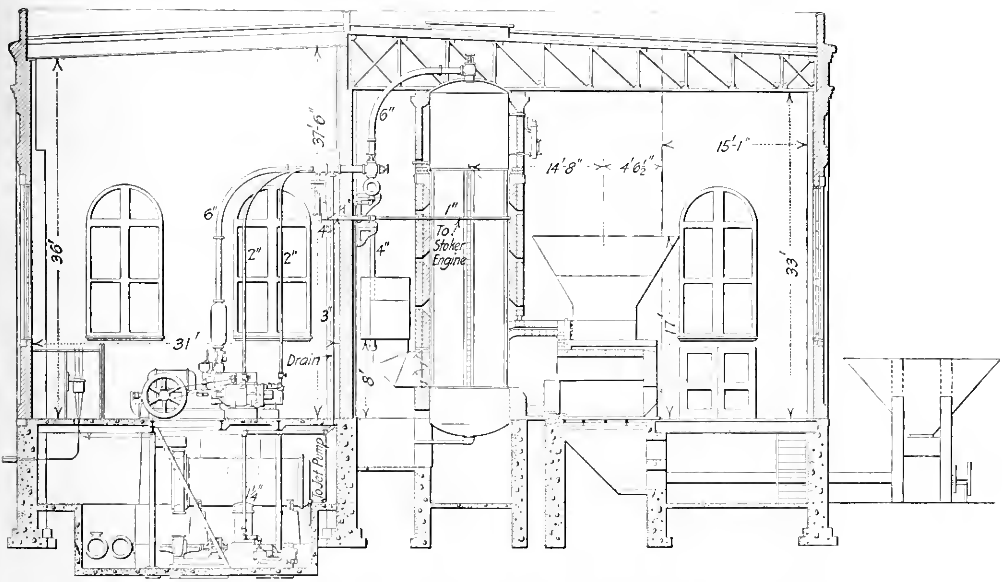


Fig. 4. Sectional Elevation through Engine and Boiler Rooms

a distributing company light and power are furnished to Harrisburg. Carrier Mills is also lighted, and the transmission line has been extended recently to Marion.

Average Load

At present the load will run about 11,000 kw.-hr. a day. At the peak hours the load is about 1200 kw., but owing to the mine and traction loads, it is erratic. From midnight to 4:30 in the morning it will not exceed 500 kw., as the services are reduced to street lighting and mine ventilation.

Generating Capacity

The plant has a capacity of 2500 kv.-a., or, at 80 per cent. power factor, 2000 kw. This is divided into two units consisting of two-stage horizontal turbines driving

Excitation is furnished by two exciters, one driven by a motor and the other by a turbine, although the former is used for the most part. Usually, one of the 300-kw. motor-generator sets carries the railway load, but in the evening it is necessary to use both. The switchboard is fully equipped with modern instruments, hand-operated oil switches for the 2300-volt current and remote control for the high-tension service. Leads from the switchboard are conducted underground in vitrified tile conduit to the transformer building located near the plant.

Boiler Plant

To serve the 2000 kw. in generating capacity there is 1600 hp. in boilers, a ratio of 5 to 4, or one boiler horsepower per 1¼ kw. The boilers are of the vertical water-tube type, contain 3977 sq.ft. of heating surface, and are rated at 400 hp. Dry steam at 160 lb. pressure is supplied to the turbines. Stokers of the top-feed type serve the boilers. Each grate has a projected area of 64 sq.ft., which bears a ratio of 1 to 62 to the boiler

FIG. 5. SPRAY NOZZLES IN ACTION

heating surface. This is high when compared to the average 1 to 50 ratio, but as the grates are set at about 45 deg., the actual area is considerably greater than the 64 sq.ft. given above. The stack rises 155 ft. above the ground, or 135 ft. above the grate level. With a gas

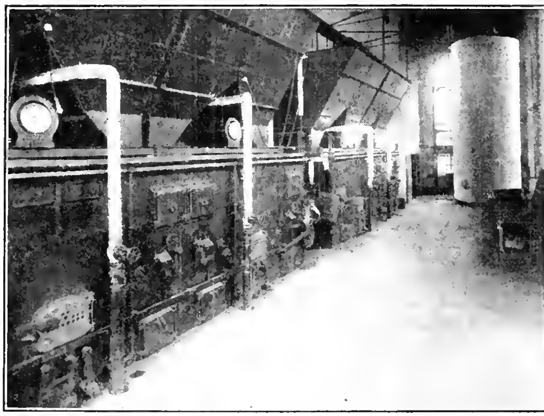


FIG. 6. THE BOILERS AND WATER PURIFIER

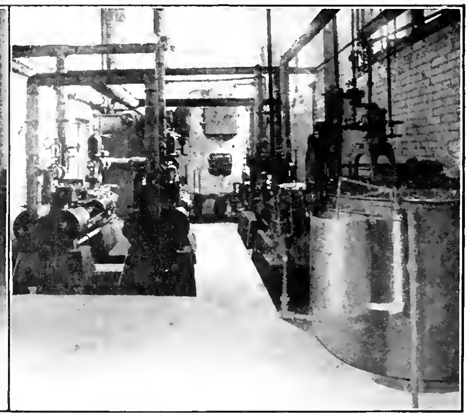


FIG. 7. PUMP ROOM, WITH CHEMICAL TANK OF PURIFIER IN FOREGROUND

temperature of 500 deg., the draft at the stack should be about 0.85 in. of water. Making the usual deductions for drop through breeching and setting, the draft over the fire for the boiler farthest from the stack should be about 0.25 in. and on the first boiler 0.35 in.

The stack, which is of concrete, is lined 50 ft. up. An internal diameter of 8 ft. gives a sectional area of 50 sq.ft. At each boiler the breeching is enlarged until at the stack it reaches a sectional area of 60 sq.ft., the width being 5 ft. and the height 12 ft. For each square foot of stack there are 1.2 sq.ft. of breeching, 5.1 sq.ft. of connected grate surface and 32 boiler horsepower.

COAL-HANDLING FACILITIES

The fuel burned is Saline County screenings. The thickness of the fuel bed is maintained at 3 to 5 in. on the inclined grates and 8 in. on the bottom. By forcing at the peaks one boiler could carry the load, but a second is carried under bank to be ready for emergencies. Under these conditions, combined with the low load factor on the generating units, the operating efficiency is low. From 5 to 6 lb. of coal is required per kilowatt-hour.

The coal is pulled over the company's track from Eldorado. It is dumped into a 30-ton hopper under the siding at the plant. From the hopper it passes through a crusher, which is operated only for lump coal, into a horizontal screw conveyor. A bucket elevator hoists it to the top of the boiler room and a second screw conveyor distributes it to 20-ton bunkers, one on top of each furnace. Ashes are wheeled from the pits to the elevator boot and are delivered to an ash screw at the top, which discharges them onto a temporary platform outside the plant, from which they may be wheeled into the empty coal cars. It is the intention to install a pneumatic system which will convey the ashes directly to the cars or a tank located beside the track.

UNUSABLE WATER TRANSFORMED INTO EXCELLENT BOILER FEED

One of the most serious problems the plant had to contend with was the water-supply. The water is taken from the Big Muddy River, which is well named, as the water retains its yellow, muddy color even in the reservoir, where it has a chance to settle. Besides containing a large amount of suspended matter, at certain seasons it is exceptionally hard and at all times is of a corrosive nature due to the acid drainage from the mines. A short period of operation showed that it would be neces-

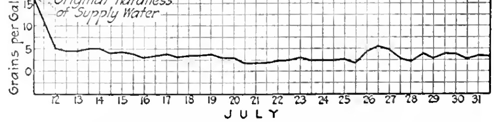


FIG. 8. CHART SHOWING HARDNESS OF WATER AFTER TREATMENT

sary to install a water softener and purifier, and this was done in the spring of 1914. The apparatus has a capacity of 2000 gal. per hr. The water from the reservoir is first pumped to a 25,000-gal. elevated tank, from which it flows to the top of the softening equipment by gravity. Here it is treated with 90 per cent. hydrated lime and 58-test soda ash, the proportions being governed by tests made twice a day. The chemicals neutralize the corrosive and scale-forming ingredients in the water and precipitate them in the form of insoluble matter. After the chemical treatment the water is allowed to settle and is then passed through a gravity quartz filter which is an integral part of the apparatus. Thence it flows by gravity into the feed-water heater and is pumped to the top drum of the boilers, although provision is also made to feed through the blowoff.

It might be stated that the river is one which varies greatly in its flow, depending upon the seasons of the year. For this reason the quality of the water varies widely, and the softener had to be adapted for accommodating the chemical charge to these variations in order to maintain a uniformly treated water. The chart, Fig. 8, shows the amount of hardening ingredients remaining in the treated water during a three-weeks' period in the month of July. The average hardness during the period is practically three grains. The following analyses, made at different periods, show the large variation in the quality of the river water.

	Mar. 4, 1914 Grains per Gal.	June 26, 1914 Grains per Gal.
Calcium carbonate	1.35	9.00
Calcium sulphate	1.97	...
Magnesium carbonate	...	...
Magnesium sulphate	3.29	9.38
Silica	5.30	...
Iron and aluminum oxides	0.75	...
Suspended matter	Undetermined	1.21
Total incrusting solids	12.66	19.59
Sodium sulphate	0.87	...
Sodium chloride	1.60	14.63
Total nonincrusting solids	2.47	14.63
Total solids	15.13	34.22

The following is an average analysis of water delivered during the past summer:

INCRUSTING SOLIDS

	Grains per Gal.
Calcium carbonate	2.10
Magnesium hydrate	1.40
Silica	0.06
Total incrusting solids	3.56

NONINCRUSTING SOLIDS

Sodium sulphate	12.06
Sodium chloride	14.32
Total nonincrusting solids	26.38
Total solids	29.94

The cost for treating the water has averaged about 1c. per 1000 gal. It varies directly with the hardening ingredients in the water, but runs from 1½c. per 1000 gal., which is the maximum, to nothing, as the supply at times contains such a large amount of rain water that it practically has no hardness. During these periods the chemical treatment is eliminated and the water is simply passed through the filter.

In the words of the chief engineer, E. H. Clark, the feed water is now ideal. The condensate from the condensers is returned to the heater and the 15 to 20 per cent. of makeup is the treated water. When the purifier was installed the boilers were thoroughly cleaned and the scale removed. Since then they have been opened up every 30 to 45 days, and washed out. During the nine months the purifier has been in service, there has been practically no scale and no evidence of corrosion.

The W. H. Schott Co., of Chicago, designed the plant and had charge of its erection, but the engineering is now under the direction of C. J. Davidson, of the firm of Woodmansee & Davidson, consulting engineers, of the same city. Under their direction the water softener and spraying nozzles were installed. They report a bright outlook for the plant. As previously stated, Marion has just been added to the list of towns taking service, and other prospects are in view which will increase the load and better the operating efficiency of the plant.

The Advantages of Small, High-Velocity Steam Piping are: Lower first cost for pipe, valves and covering, etc., less erecting and maintenance cost; less weight; less radiation loss; less chance for water to accumulate and less difficulty with valves of smaller size.

To Increase Industrial Prosperity this country needs to export finished rather than crude products and to import raw materials rather than manufactures. Betterment of industrial conditions can come best through expansion of manufacturing. The increase of the element of labor in the product exported will mean that we are not bartering away our heritage of natural resources, but rather that we are using these resources as a basis simply for the expenditure of labor, which renews itself—George Otis Smith, Director, United States Geological Survey.

PRINCIPAL EQUIPMENT OF SOUTHERN ILLINOIS RAILWAY & POWER CO.'S PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Vertical water-tube	400 hp.	Generate steam	160-lb. pressure, natural draft, stokers	Wickes Boiler Co.
4	Stokers	Top-feed	Projected area, 64 sq.ft.	Serve boilers	Draft over fire 0 25 to 0 35 in	Murphy Iron Works
1	Stack	Concrete	155 ft. high, 8 ft. diam.	Natural draft for boilers		GeneralConcreteConstructionCo
1	Coal conveyor	Screw-and-bucket	20 tons per hr.	Transfer coal from car to bunker	Driven by 20-hp. induction motor	A. Lucas & Sons
1	Coal crusher		20 tons per hr.	Crush lump coal	Driven by 20-hp. induction motor	A. Lucas & Sons
1	Water softener	Cold process	2000 gal. per hr.	Soften boiler feed		Wm. Graver Tank Works
1	Heater	Open	1600 hp.	Heat boiler feed water	Exhaust from auxiliaries	Platt Iron Works Co.
2	Pumps	Duplex	10x6x12-in.	Feed boilers	160 lb. steam	Platt Iron Works Co.
2	Pumps	Duplex	6x7x10-in.	Water from reservoir to tank	160 lb. steam	Platt Iron Works Co.
1	Air compressor	Locomotive	9¼x9¼x10-in.	Blowing flues, etc.	160 lb. steam	Westinghouse Air Brake Co.
2	Turbines	2-stage, horizontal, Curtis	1000-kw.	Main units	Drive at 3600 r.p.m., three-phase, 60-cycle, 2300-volt generators	General Electric Co.
2	Condensers	Surface	3600 sq.ft.	Serve main units		Platt Iron Works Co.
2	Pumps	Dry-vacuum	10x18x18-in.	Serve condensers	160 lb. steam	Platt Iron Works Co.
2	Pumps	Centrifugal	3000 gal. per min.	Condenser circ. water	Driven 1250 r.p.m. by 50-hp. ind. motors	Platt Iron Works Co.
2	Pumps	Duplex	7x5x6-in.	Condensate pumps	160-lb. steam	Platt Iron Works Co.
75	Spray nozzles		2-in. base, ¾-in. nozzle	Cool condenser water		Spray Engineering Co.
1	Exciter	Turbine-driven	35-kw.	Excitation for main units	125-volt, 3600 r.p.m.	General Electric Co.
1	Exciter	Motor-driven	50-kw.	Excitation for main units	125-volt, 1200 r.p.m., motor 75 hp., ind., 2300-volt	General Electric Co.
2	Motor-generator sets	Railway	300-kw.	Railway service	2300-volt synchronous motor, 430 hp., 720 r.p.m., 1200-volt, constant-current generator.	General Electric Co.

Interior Wiring for Lighting and Power Service--IV

By A. L. Cook

SYNOPSIS—The previous articles of the series covered the layout and wiring calculations for lighting systems; the present and succeeding installments cover power circuits, including location of motors and control devices, determination of load, voltage drop and wiring calculations.

It is beyond the scope of this article to discuss the types of motors best suited for various industrial conditions, but the location of motors and the choice of control devices will be considered before taking up the wiring. The location of the motor will be, to a large extent, fixed by that of the driven machine. If there is a choice, however, it should be placed where it can be easily reached for inspection, and also where it will be protected, as far as the surroundings permit, from moisture, dust and accumulations of dirt. It is desirable to avoid where possible the use of entirely inclosed motors because of their greater cost. Control devices also should be selected with regard to where they are to be used and the class of labor which is to operate them. They should be placed in the position most convenient for the operation of the motor and should always include a switch located in sight of the motor, by means of which all wires running to the motor or control device can be disconnected from the supply. This is necessary to facilitate repairs and is a safeguard against operation by unauthorized persons. If the motors are supplied from near-by panel-boards, these switches can be placed on the panels.

The systems of distribution for power include two-wire alternating or direct current, and three-phase or two-phase alternating current. The standard voltages for direct-current motor service have already been specified. A voltage of 115 should be used only where the motors are small and the feeders short. The best voltage for usual conditions is 230, as this gives reasonably small conductors, even for long runs. One advantage of this voltage is that the supply can easily be made three-wire for lighting and two-wire (230 volts) for the motors. A voltage of 550 should be used only where the feeders are very long and the motors large. The panel-boards and control devices will be much larger than for the other voltages, and the cost of maintenance of the system under usual factory conditions will be greater. There is also greater danger of injury to the workmen than with lower voltages. This high voltage is not at all adapted for power supply in an office building and is seldom used for that purpose.

A two-wire alternating-current system (single-phase system) is adapted only to supplying motors up to about 15 hp. With alternating current, either the three-phase or the two-phase system is ordinarily used. The former is best adapted for the usual power supply in factories, the two-phase system being used principally by central stations, where the lighting and motor loads are carried on the same distributing system; in which case the two-phase system is easier to balance than the three-phase. It is possible, however, to operate either system satisfactorily in this way. For an isolated plant, however, the three-phase system is preferable; the lighting load being taken from one or more phases, depending on its relative importance compared with the power load. The choice between 25 and 60 cycles is influenced by the fact that the latter is better for lighting and the cost of the motors is somewhat less. There is also the advantage of a greater number of available speeds in 60-cycle motors for the range usually needed.

Choice of Motors

Alternating-current motors have definite speeds, fixed by the frequency and depending upon the number of poles, whereas direct-current motors have greater flexibility in this respect. The available no-load speeds for alternating-current motors for the usual range are given in Table 10. The highest speed is for the two-pole motor, and the speed can be made as low as required by providing a suitable number of poles. It will be seen by reference to this table that for 25 cycles motors can be built for only three speeds between 500 r.p.m. and the maximum; whereas for 60 cycles there are seven speeds. All of these speeds cannot be obtained from the same motor, which, on the contrary, must be built for a particular speed, and only by special design can it be run at more than one of these speeds; even then the number of available speeds is limited to two.

The alternating-current system is generally better suited for factory power supply than the direct-current, because of the greater reliability and ruggedness of the alternating-current motor. The standard alternating voltages available for general use with either three-phase

TABLE 10—AVAILABLE SPEEDS FOR ALTERNATING-CURRENT MOTORS

Number of Poles	No-Load Speed, R.p.m.— 60 Cycles	25 Cycles
2	3600	1500
4	1800	750
6	1200	500
8	900	375
10	720	300
12	600	250
14	514	214

or two-phase systems are 110, 220, 440 or 550 volts, and for large motors 2200 volts. The ease with which the voltage may be changed to suit conditions allows great flexibility in the choice of a voltage for the motors. Either 220 or 440 volts is commonly used, the lower voltage being preferable for moderate-sized installations, particularly where the supervision may be in relatively unskilled hands. The danger of workmen receiving fatal shocks is greater with alternating than with direct current, and 440 or 550 volts presents a real hazard in this respect; shock from 220 volts is seldom fatal. In establishments of considerable size, particularly with large motors, the great saving in feeder size with 440 or 550 volts results in their frequent use.

More complete protection is permissible with alternating than with direct current, so that with careful planning of the control devices and first-class wiring, these higher-voltage systems can be made fairly safe. Sometimes 1100 or 2200 volts are used for alternating-current motor drive, but as such a high voltage is adapted only for large motors and requires special methods of installation of the wiring and control system to make it safe, these will not be considered in this article.

The common types of direct-current motors are the shunt motor, which is practically constant-speed, and the series motor, which gives variable speed. While the former is called a constant-speed machine, since the speed is practically constant from no load to full load, the speed can be adjusted through a wide range by changing the resistance in either the field or the armature circuit, the former method being preferable. The shunt motor is adapted for any constant-speed service, such as driving machine tools, woodworking machinery, fans, and the like, while the series motor is best adapted for driving cranes, hoists and similar devices. For some purposes a compound motor, which combines the characteristics of the series and shunt, is best; the principal applications of this type being found in the driving of elevators, punch-presses, planers, etc.

The usual type of alternating-current motor is the induction motor, which may be of the squirrel-cage or the wound-rotor type. The former is the most rugged and the simplest kind of motor made, and is cheaper and more satisfactory for general use than the wound-rotor type. A disadvantage is that it cannot start under heavy load without taking a large current from the line, but where the starting load is less than full load and a constant speed is required, the squirrel-cage motor should be used. If the driven machine requires a large starting torque, as for example, a compressor starting under full pressure, or if the speed must be adjusted, then the wound-rotor type must be used. Sometimes it is desirable to use this type of motor for constant-speed service when the size of the motor is large compared with the capacity of the generator supplying the load, because of the great drop in voltage caused by starting a large motor.

The full-load current required by a motor is always marked on the nameplate, but it is frequently necessary to lay out the wiring before the motors have been received. To assist in estimating the load, Tables 11, 12 and 13 have been prepared. The full-load currents given are for direct-current motors and for the usual type of alternating-current induction motors. For the direct-current motors, the "National Electric Code" requires that the size of wires shall be sufficient to carry at least a 25-per cent. overload and the usual motor for continuous service is designed to carry a 25-per cent. overload for two hours.

TABLE 11—CURRENT AND SIZE OF WIRE FOR DIRECT-CURRENT MOTORS

Horsepower	Amperes, Full Load 115 V.	230 V.	550 V.	Size of Wire* Rubber Insulation 115 V.	230 V.	550 V.	Other Insulation 115 V.	230 V.	550 V.
0.5	5	2.5	1.1	14	14	14	14	14	14
1	8.8	4.4	1.8	14	14	14	14	14	14
2	16	8	3.4	10	12	14	14	14	14
3	24	12	5	8	12	14	8	14	14
5	40	20	8.4	5	8	14	6	10	14
7.5	58	29	12.1	3	6	12	5	8	14
10	76	38	15.9	1	5	10	3	6	12
15	112	56	23.4	00	3	8	1	5	10
20	146	73	30.5	0000	1	6	0	3	8
25	182	91	38.1	250,000	0	6	000	2	8
30	216	108	45.2	350,000	00	4	000	1	6
35	252	126	52.6	400,000	000	4	0000	0	6
40	288	144	60.2	500,000	0000	3	300,000	0	5
50	356	178	74.4	600,000	250,000	1	350,000	000	3
60	428	214	89.5	800,000	350,000	0	500,000	000	2
75	532	266	111	1,100,000	450,000	00	600,000	250,000	1
100	710	355	148	1,700,000	600,000	0000	900,000	350,000	0
125	886	443	185	two 850,000	850,000	300,000	1,200,000	500,000	00
150	1076	535	224	two 1,100,000	1,100,000	400,000	1,600,000	700,000	0000

*Allows at least 25 per cent. overload.

The sizes of wire specified in Table 11 are such that the motor can carry from 25 to 30 per cent. overload without exceeding the current rating of the wire in accordance with the "Code" rules. To find the current and size of wire for a motor not given in the table, find the amperes per horsepower for the next smallest motor, and then multiply by the horsepower of the given motor. For example, to find the current for a 65-hp. 550-volt direct-current motor, we find that the current per horsepower is $\frac{89.5}{60} =$ 1.49 amp. The full-load current for a 65-hp. motor is then 1.49 × 65 = 97 amp. Allowing 25 per cent. overload, the current would be 121 amp., and if rubber-covered wire is used the size would be No. 0.

TABLE 12—CURRENT AND SIZE OF WIRE FOR THREE-PHASE INDUCTION MOTORS, SQUIRREL-CAGE TYPE

Horse-power	Amperes, Full Load 110 V.	220 V.	440 V.	550 V.	Size of Wire, Rubber or Other Insulation 110 V.	220 V.	440 V.	550 V.
*0.5	3.6	1.8	0.9	0.7	14	14	14	14
*1.0	6.4	3.2	1.6	1.3	12	14	14	14
*2.0	11.6	5.8	2.9	2.3	8	12	14	14
*3.0	16.4	8.2	4.1	3.3	6	8	14	14
5.0	26.8	13.4	6.7	5.4	5	8	12	12
7.5	39.2	19.6	9.8	7.9	21	6	10	12
10.0	53.2	26.6	13.3	10.7	0	5	8	8
15.0	77.0	38.6	19.3	15.5	00	2	6	8
20.0	109.0	54.6	27.3	21.8	0000	0	5	6
25.0	125.0	62.6	31.3	25.1	300,000	0	4	5
35.0	...	85.6	42.8	34.3	....	000	2	3
50.0	...	122.0	61.0	48.6	....	250,000	0	1
75.0	...	179.0	89.0	72.0	....	450,000	000	0
100.0	...	237.0	118.0	95.0	....	600,000	250,000	000
150.0	...	353.0	176.0	141.0	....	1,100,000	400,000	300,000
200.0	...	451.0	226.0	181.0	....	(2) 600,000	600,000	450,000
250.0	...	560.0	280.0	224.0	....	(2) 800,000	800,000	600,000
300.0	...	670.0	335.0	268.0	....	(2) 1,000,000	1,000,000	800,000

*These motors are thrown directly on the line; all others are provided with auto-starters set to give a starting torque equal to full-load running torque.

The allowance mentioned for overload would be sufficient in the majority of cases; but if the motor is subject to heavy momentary overloads, as for example in the case of a planer drive, a larger overload should be allowed. There is a disadvantage in fusing the motor too high, as it is then not protected against continuous overload which might burn out the motor. For alternating-current motors also, the "Code" requires that the wire shall be sufficient to allow at least 25 per cent. overload. Tables 12 and 13 give data for three-phase and two-phase induction motors, the full-load current values being for modern, high-efficiency motors. These values apply more particularly to the squirrel-cage type; for wound-rotor type of motor the full-load currents would be slightly greater. Squirrel-cage induction motors take very large currents from the line when starting, averaging about 2.9 times the full-load value with a torque equal to full-load running torque. To obtain this starting torque, about 85 per cent. of full-load voltage is applied to the motor. Usually, the load driven by a squirrel-cage motor is such that a voltage of 65 per cent. can be used, and then the starting current will be only about 2.2 times full-load current. A wound-rotor type of induction motor, starting under full load, takes about 25 per cent. more than the full-load current when running.

Because of the heavy starting current required for squirrel-cage induction motors, the rules allow the leads to be selected in accordance with column B of Table 7 (see page 642, May 11 issue) even when rubber-covered wire is used. The sizes specified in Tables 12 and 13 are chosen on this basis. For wires with other insulation the same allowance is not made; that is, according to the "Code," the wire must be chosen in accordance with column B also. However, the inspectors will often allow induction-motor wires when exposed to be fused somewhat higher than the values given in column B. It is apparent that the wires will be adequately protected from injury when fused in accordance with these rules, but the motor will not be properly protected against continuous overloads, which would not cause the fuses to blow, but still would be larger than the motor could safely stand for any length of time. It is customary, therefore, to provide "running fuses" which are not in circuit during starting. The ordinary induction motor is rated to stand a 25-per cent. overload for two hours, but can carry greater loads for short periods. Therefore, the running fuses should have a rating about 50 per cent. greater than the full-load current of the motors.

The rules given for determining the proper size of wire and the fusing of motors apply to motors intended for continuous service, which are designed to carry their rated load continuously or to carry a 25-per cent. overload for two hours. There are certain other kinds of service, such as cranes and elevators, where the load is intermittent and the motor is required to carry heavy momentary loads. The sizes of fuses and wires for this service are chosen somewhat differently, the motors being rated at the load which they will carry for 30 min. without exceeding a safe temperature. Direct-current motors for intermittent service will, however, carry a 50-per cent. overload for short periods without injury and will carry a 100-per cent. overload momentarily without injurious sparking. Alternating-current motors are also rated on a 30-min. basis, and since they have no commutator, will stand for short periods large overloads, amounting to 2 or 2½ times full-load current. Direct-current motors for intermittent service should be provided with fuses allowing at least 50 per cent. overload, and the branch circuits for the motors must therefore be sufficient to carry this current. If rubber-insulated wire is used, column A of Table 7 should be used; for other insulations column B should be employed. In the case of alternating-current motors, the "Code" specifies definitely the current rating for the branch circuits; the values given are as follows:

Service	Percentage of Current Rating of Motor
Operating valves, raising or lowering rolls, tool heads, etc.	200
Hoists, rolls, ore- and coal-handling machines	180
Freight elevators, shop cranes	160
Passenger elevators	140
Rolling tables, pumps	120

This applies to varying-speed alternating-current motors: that is, where the speed changes with varying loads, as in the series direct-current motor, the current referred to being rated for the 30-min. load rating, as previously mentioned. The size of wire must be selected by using either column A or B of Table 7, depending upon the insulation.

In general each feeder will supply a number of motors and in order to calculate its size the probable maximum current to be carried by the feeder must be determined. For usual factory conditions this would be considerably less than the sum of the full-load currents of the motors connected to the feeder. It would seldom occur that all the motors would be carrying full load at the same time. Consequently, a load factor must be assumed, the term load factor meaning the ratio of the maximum to the total connected load. This may vary from 40 to 80 per cent., depending upon the nature of the work and the number and size of motors on the feeder. Where there is a large number of small motors, this factor would be less than where there are a few large motors on the system. For ordinary factory conditions, in the absence of better information, the load factor for the feeders may be taken as 75 per cent. of the rated load of the motors. With alternating current the size of wire should be checked by assuming the largest motor starting and all the others running, allowing 75 per cent. of the full-load current for these motors.

TABLE 13—CURRENT AND SIZE OF WIRE FOR TWO-PHASE INDUCTION MOTORS, SQUIRREL-CAGE TYPE

Horse-power	Amperes, Full Load† 110 V.	220 V.	440 V.	550 V.	Size of Wire, Rubber or Other Insulation 110 V.	220 V.	440 V.	550 V.
*0.5	3.2	1.6	0.8	0.6	14	14	14	14
*1.0	5.6	2.8	1.4	1.1	14	14	14	14
*2.0	10.0	5.0	2.5	2.0	8	14	14	14
*3.0	14.4	7.2	3.6	2.9	6	10	14	14
5.0	23.2	11.6	5.8	4.7	6	8	12	14
7.5	34.0	17.0	8.5	6.8	3	8	12	14
10.0	46.0	23.0	11.5	9.2	1	6	8	10
15.0	66.8	33.4	16.7	13.4	0	3	8	8
20.0	94.4	47.2	23.6	18.9	000	1	6	6
25.0	108.4	54.2	27.1	21.7	0000	1	5	6
35.0	...	74.2	37.1	29.7	....	00	2	4
50.0	...	105.0	52.6	42.1	....	0000	0	2
75.0	...	155.0	77.3	61.9	....	350,000	00	0
100.0	...	205.0	103.0	82.0	....	500,000	0000	000
150.0	...	306.0	153.0	123.0	....	900,000	350,000	300,000
200.0	...	390.0	195.0	156.0	....	(2) 500,000	500,000	400,000
250.0	...	484.0	242.0	194.0	....	(2) 700,000	700,000	500,000
300.0	...	580.0	290.0	232.0	....	(2) 800,000	800,000	600,000

*These motors are thrown directly on the line; all others are provided with auto-starters set to give a starting torque equal to full-load running torque.

†Values of current are for a two-phase, four-wire system; if three wires are used, current in common wire would be 1.42 times value given.

The allowable voltage drop for power circuits can be greater than for lighting circuits, but should not be too large, particularly with induction motors, as they do not operate satisfactorily at voltages greatly below normal. A total of 5 per cent. drop, figured from the motor to the service point or the power-house switchboard, is satisfactory and does not require excessive feeder sizes. This voltage drop should be divided about as follows: Individual motor circuits, 1.75 per cent.; feeders and subfeeders, 3.25 per cent.; total, 5 per cent.

Direct-current motor circuits can be calculated by means of the wiring chart already described (see page 667 May 18 issue). Alternating-current circuits cannot be calculated as easily. This is because of the power factor of the motor circuits, which is generally about 0.80. The effect of this power factor is to make the drop greater than if it were 1.00, as in the case of lighting loads. The extent to which the drop is thus increased depends upon the spacing between wires, the effect being least when the wires are in one conduit and increasing very rapidly when they are separated and run on insulators. When all the wires of a circuit are run in the same conduit the drop is practically the same as for direct current, for wires not greater than No. 0 for 60-cycle circuits and not larger than 300,000 circ.mils for 25 cycles. The wiring chart which was used in lighting calculations can therefore be used for such cases. For larger wires run in conduit and for all wires separated a considerable distance, as in exposed work, the drop must be calculated by other means. The simplest method is to determine the drop in the usual manner, by means of the direct-current chart already explained, and then to determine the additional drop which would be caused by the inductive effect. A method for doing this has been developed by

C. F. Scott and C. P. Fowler and was published in the April, 1907, issue of *The Electric Journal*.

The drop due to inductance depends upon the ratio of reactance to resistance and also upon the power factor. The reactance depends upon the frequency and upon the spacing between wires. We require, then, a table giving this ratio for the particular spacing of the wires and the proper frequency and also a table giving the drop factor corresponding to various values of this ratio. Tables 14 and 15 give these quantities.

An example in the use of these tables will assist in understanding the method employed. Assume a No. 00 wire carrying a single-phase alternating current of 50 amp. a distance of 150 ft. at a frequency of 60 cycles. The drop, if direct current were used, is found by the chart (page 667, May 18 issue) to be 1.2 volts. Assuming the wires are all in the same conduit, it will be seen from Table 14 that the ratio of reactance to resistance is 0.54. Assume that the load consists of incandescent lamps, so that the power factor may be taken as 1.0. Then the drop factor is found from Table 15 to be 1.004. That is, the direct-current drop of 1.2 volts must be multiplied by 1.004, which gives 1.205 volts. Hence the alternating-current drop under these conditions is practically the same as the direct-current drop. If the wires are 6 in. apart the ratio would become 1.04, the drop factor would be 1.044 and the alternating-current drop would be 1.25 volts. If the power factor is 0.8, the drop factor would be 1.42 and the alternating-current drop would be 1.70 volts. It will be seen that for a power factor of 1.0 the alternating-current drop is practically equal to the direct-current drop for ratios up to 0.7, being only 1 per cent. higher for 0.6. For lower power factors, however, the alternating-current drop is, in general, different from, and may be less than, that for direct current. Therefore, it is necessary to estimate this in each case. Table 16 gives the usual values of the power factor for various kinds of loads. The values for induction motors assume that all the motors on a feeder would not be carrying full load at the same time. The power factor of induction motors when carrying full load is in general greater than the values herewith given.

The values refer to the sizes of the individual motors on the feeder. That is, if a feeder carried one 15- and four 10-hp. motors the total connected motor load would be 55 hp., but the power factor on the feeder should be taken as 0.80. By examining Tables 14 and 15 it will be noted that the alternating-current drop increases very rapidly as the size of wire increases. As a rule, wires larger than 300,000 circ.mils should be avoided, except

TABLE 14—RATIO OF REACTANCE TO RESISTANCE

Size of Wire	Ratios for Distance between Wires of— In Conduit	2½ In.	4 In.	5 In.	6 In.	8 In.	12 In.
	60 Cycles						
10	0.05	0.09	0.10	0.11	0.11	0.12	0.13
8	0.08	0.13	0.15	0.16	0.17	0.18	0.19
6	0.12	0.21	0.23	0.24	0.26	0.27	0.29
5	0.14	0.25	0.28	0.30	0.31	0.33	0.36
4	0.15	0.30	0.34	0.36	0.38	0.41	0.44
3	0.22	0.37	0.42	0.45	0.47	0.50	0.54
2	0.26	0.45	0.52	0.55	0.57	0.62	0.67
1	0.32	0.54	0.62	0.67	0.70	0.75	0.82
0	0.38	0.66	0.77	0.82	0.86	0.92	1.01
00	0.54	0.80	0.93	0.99	1.04	1.13	1.25
000	0.64	0.97	1.14	1.21	1.28	1.38	1.53
0000	0.76	1.17	1.38	1.48	1.56	1.70	1.87
300,000	1.01	1.54	1.84	1.98	2.10	2.28	2.52
400,000	1.49	1.93	2.33	2.52	2.67	2.92	3.26
500,000	1.75	2.30	2.80	3.03	3.22	3.54	...
600,000	1.85	2.52	3.10	3.40	3.63	...	...
700,000	2.06	2.84	3.54	...	...	...	...
800,000	2.49	3.12	...	...	...	...	...
900,000	2.69	3.39	...	...	...	...	...
1,000,000	2.89	3.66	...	...	...	...	...
	40 Cycles						
10	0.03	0.06	0.07	0.07	0.07	0.08	0.09
8	0.05	0.09	0.10	0.11	0.11	0.12	0.13
6	0.08	0.14	0.15	0.16	0.17	0.18	0.19
5	0.09	0.17	0.19	0.20	0.21	0.22	0.24
4	0.10	0.20	0.23	0.24	0.25	0.27	0.29
3	0.15	0.25	0.28	0.30	0.31	0.33	0.36
2	0.17	0.30	0.35	0.37	0.38	0.41	0.45
1	0.21	0.36	0.41	0.45	0.47	0.50	0.55
0	0.25	0.44	0.51	0.55	0.57	0.61	0.67
00	0.36	0.53	0.62	0.66	0.69	0.75	0.83
000	0.43	0.65	0.76	0.81	0.85	0.92	1.02
0000	0.51	0.78	0.92	0.99	1.04	1.13	1.25
300,000	0.67	1.02	1.22	1.32	1.40	1.52	1.67
400,000	1.00	1.28	1.55	1.68	1.77	1.95	2.17
500,000	1.17	1.53	1.87	2.02	2.14	2.36	2.43
600,000	1.23	1.68	2.07	2.27	2.42	2.67	3.02
700,000	1.38	1.90	2.36	2.58	2.76	3.05	3.45
800,000	1.67	2.08	2.63	2.87	3.08	3.40	...
900,000	1.80	2.27	2.87	3.15	3.38	...	...
1,000,000	1.93	2.45	3.08	3.40	3.67	...	...
	25 Cycles						
10	0.02	0.04	0.04	0.05	0.05	0.05	0.05
8	0.03	0.05	0.06	0.07	0.07	0.08	0.08
6	0.05	0.09	0.10	0.10	0.11	0.11	0.12
5	0.06	0.10	0.12	0.13	0.13	0.14	0.15
4	0.06	0.12	0.14	0.15	0.16	0.17	0.18
3	0.09	0.15	0.18	0.19	0.20	0.21	0.23
2	0.11	0.19	0.22	0.23	0.24	0.26	0.28
1	0.14	0.23	0.26	0.28	0.29	0.31	0.34
0	0.16	0.28	0.32	0.34	0.36	0.38	0.42
00	0.23	0.33	0.39	0.41	0.43	0.47	0.52
000	0.27	0.40	0.48	0.51	0.53	0.58	0.64
0000	0.32	0.49	0.58	0.62	0.65	0.71	0.78
300,000	0.42	0.64	0.77	0.83	0.88	0.95	1.05
400,000	0.62	0.81	0.97	1.05	1.11	1.24	1.36
500,000	0.73	0.96	1.17	1.26	1.34	1.48	1.65
600,000	0.77	1.05	1.29	1.42	1.51	1.67	1.88
700,000	0.86	1.18	1.47	1.61	1.72	1.91	2.15
800,000	1.06	1.30	1.64	1.79	1.92	2.12	2.31
900,000	1.12	1.42	1.79	1.96	2.11	2.34	2.49
1,000,000	1.29	1.53	1.92	2.12	2.29	2.54	...

TABLE 15—DROP FACTORS*

Ratio of Reactance to Resistance	Drop Factors for Power Factors of— 1.00	0.95	0.90	0.85	0.80	0.70	0.60	0.40
0.1	1.00	1.00	1.00	0.94	0.88	0.80	0.70	0.60
0.2	1.00	1.01	1.01	0.98	0.92	0.86	0.82	0.67
0.3	1.00	1.05	1.05	1.02	0.99	0.93	0.89	0.74
0.4	1.00	1.08	1.10	1.08	1.04	1.00	0.93	0.82
0.5	1.00	1.11	1.14	1.13	1.10	1.07	1.01	0.92
0.6	1.01	1.15	1.18	1.19	1.15	1.14	1.09	1.01
0.7	1.02	1.18	1.23	1.24	1.21	1.20	1.17	1.11
0.8	1.02	1.21	1.28	1.29	1.28	1.27	1.24	1.20
0.9	1.03	1.25	1.33	1.34	1.34	1.35	1.32	1.29
1.0	1.04	1.28	1.37	1.39	1.40	1.41	1.39	1.38
1.1	1.05	1.32	1.41	1.44	1.45	1.48	1.47	1.46
1.2	1.06	1.35	1.46	1.50	1.51	1.55	1.54	1.55
1.3	1.07	1.39	1.51	1.55	1.57	1.62	1.63	1.64
1.4	1.08	1.43	1.55	1.61	1.64	1.70	1.71	1.72
1.5	1.10	1.47	1.60	1.67	1.70	1.77	1.80	1.81
1.6	1.10	1.51	1.65	1.74	1.77	1.85	1.87	1.90
1.7	1.13	1.55	1.70	1.79	1.84	1.92	1.95	1.99
1.8	1.15	1.59	1.76	1.85	1.91	1.99	2.04	2.08
1.9	1.17	1.63	1.82	1.91	1.98	2.06	2.11	2.16
2.0	1.18	1.68	1.87	1.96	2.04	2.14	2.19	2.25
2.1	1.20	1.72	1.92	2.03	2.10	2.21	2.28	2.35
2.2	1.22	1.77	1.98	2.09	2.17	2.29	2.37	2.45
2.3	1.23	1.82	2.03	2.15	2.23	2.37	2.45	2.53
2.4	1.25	1.87	2.09	2.22	2.30	2.44	2.53	2.62
2.5	1.27	1.91	2.14	2.28	2.37	2.52	2.60	2.71
2.6	1.30	1.95	2.20	2.34	2.44	2.60	2.67	2.80
2.7	1.32	1.99	2.26	2.41	2.51	2.68	2.74	2.98
2.8	1.35	2.05	2.32	2.47	2.57	2.76	2.82	3.07
2.9	1.37	2.10	2.39	2.54	2.64	2.83	2.91	3.15
3.0	1.40	2.15	2.45	2.60	2.72	2.90	3.00	3.23
3.1	1.42	2.20	2.51	2.66	2.80	2.97	3.10	3.31
3.2	1.45	2.26	2.57	2.73	2.87	3.05	3.20	3.39
3.3	1.48	2.31	2.63	2.80	2.93	3.12	3.30	3.47
3.4	1.51	2.36	2.69	2.87	3.00	3.20	3.39	3.56
3.5	1.53	2.42	2.74	2.94	3.08	3.27	3.48	3.65
3.6	1.57	2.47	2.80	3.00	3.15	3.35	3.56	3.75
3.7	1.60	2.52	2.86	3.07	3.23	3.43	3.65	3.85

*Reprinted by permission from "The Electric Journal," Vol. IV, p. 299.

TABLE 16

	Power Factor
Incandescent lamps of all kinds	1.00
Arc lamps, including flaming arcs	0.65
Induction motors (running) up to 15 hp.	0.80
Above 15 hp.	0.85

where the wires are in conduit, when a size of 500,000 circ.mils or larger may be used. If larger wires are required to carry the load two or more can be employed in parallel. For example, find the drop on a 500,000-circ.-mil feeder carrying 300 amp. a distance of 500 ft. The direct-current drop is 6.1 volts. If the frequency is 60 cycles, the power factor 0.8 and the spacing 6 in., the drop factor is 2.88 and the alternating-current drop is 18.4 volts. No. 0000 cable is about one-half the size of 500,000-circ.mil cable; therefore, calculate the drop, using two No. 0000 cables instead of a single wire. The current per cable would be 150 amp., the direct-current drop would be 7.6 volts and the drop factor 1.74. Hence, the alternating-current drop would be only 13.2 volts, which is considerably less than for the single cable. Figuring the size of wire to give the same voltage drop as before (18.4 volts), we find that a No. 00 cable gives an alternating-current drop of 17.2 volts. That is, two No. 00 cables having a total cross-section of 266,200 circ.mils will carry a total load of 300 amp. with less drop than for a single 500,000-circ.mil cable with a great saving in copper. This saving often exceeds the additional cost of running two circuits instead of one, so this point should always be kept in mind when laying out alternating-current circuits. In this connection, it should be stated that wires which are run in multiple, as in the above case, should always be of the same size. For example, if a 500,000- and a 300,000-circ.mil cable were employed to take the place of one of 800,000 circ.mils the smaller wire would take more than its share of the load, and in some cases, might be overheated. This method can also be used for the calculation of three-phase and two-phase circuits by making certain modifications which will be explained later.

Hilliard Rack-and-Pinion Clutch Shifter

An interesting clutch-shifting device for use with the Hilliard clutch and manufactured by the Hilliard Clutch & Machinery Co., Elmira, N. Y., is illustrated in Fig. 2.

While to date this mechanism has been used exclusively in connection with Hilliard clutches, its application is not confined to this particular make, but it is equally adaptable to any clutch which has a sliding member for engaging and in which can be cut the necessary groove to accommodate the clutch-shifter yoke.

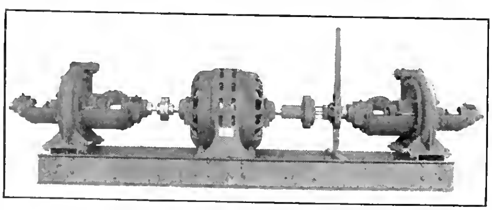


Fig. 1. Shifter on Clutch between Pump and Motor

This device is made either in solid or split form, and the operating mechanism is held in a set position on the shaft by two safety collars; the thrust for engaging the clutch is obtained by means of the rack and pinion. For operating the pinion, several devices may be employed, but preferably a handwheel, which can be attached by a key or a setscrew to the stub pinion shaft or to an extension shaft coupled to the short shaft provided. The device is convenient under certain conditions, say when it is desired to operate a clutch from the opposite side of a brick wall. In one case a 12-ft. extension shaft was attached to the short pinion shaft by a coupling, common pillow blocks being used for a bearing in the wall. On the end of the shaft an ordinary handwheel was attached, and although separated from the shaft by a brick wall, the operator had perfect control of the clutch.

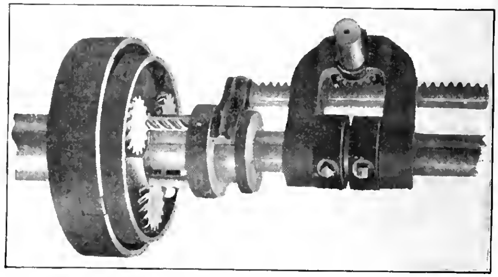


Fig. 2. Rack-and-Pinion Clutch Shifter

There are many places where this device would prove useful. It is manufactured in three sizes. No. 1 size will accommodate a 2-in., No. 2 a 3-in. and No. 3 a $4\frac{7}{16}$-in. shaft. The yoke, suspended from the shaft, is equipped with grease cups which provide ample lubrication, and the device is efficient.

Fig. 1 illustrates an 8½-in. clutch of 7½-hp. capacity and shifter on the shaft of a 15-hp. motor that is used for driving two pumps running at 1200 r.p.m. One pump is coupled to the motor shaft direct, the other by means of the clutch. The convenience of the arrangement is apparent.

The Area of Chimneys should be proportioned to the quantity and quality of the fuel consumed per hour. Isherwood determined by experiments that the stack area should be from one-sixth to one-eighth the area of the grate, modified by the velocity of the gas. This in turn is influenced by the temperature of the gas and the height of the stack.

Safety-Valve Capacity—Below is given the number of square feet of heating surface served by a single 4-in. pop safety valve at 100 lb. gage pressure, under the requirements of the various rules noted. The assumption is made that the ratio between grate surface and heating surface is 1 to 40, and in such rules as require the rate of combustion to be assumed, it has been taken at such rate as would cause the evaporation of 160 lb. of water per square foot of grate surface per hour.

	Sq.Ft.
U. S. Government rule $\left(a = 0.2074 \frac{\text{weight of water evaporated per hr.}}{\text{absolute pressure}}\right)$	1740
Massachusetts rule $\left(a = 0.2139 \frac{\text{weight of water evaporated per hr.}}{\text{absolute pressure}}\right)$	1700
Ohio rule (same as Mass.)	1700
Detroit rule (same as Mass.)	1700
Memphis rule (same as Mass.)	1700
Board of Trade rule $\left(\frac{37.5}{\text{absolute pressure}}\right)$	1540
Newfoundland (same as Board of Trade rule)	1540
Alberta (same as Board of Trade rule)	1540
British Columbia (same as Board of Trade rule)	1540
Saskatchewan (same as Board of Trade rule)	1540
Ontario (same as Board of Trade rule)	1540
Philadelphia $\left(\frac{22.5}{\text{gage pressure} + 8.62}\right)$	2390
Indiana (0.33 sq.in. per sq.ft. grate)	1510
Average	1670
A.S.M.E. Boiler Code for water-tube boilers	1006
A.S.M.E. Boiler Code for fire tube boilers	1208

Will Quizz, Jr.

SYNOPSIS—Our observant friend, Will, while reading the advertising section of his technical journal, sees a statement that he cannot verify, so he carries the problem to Chief Teller.

"Say, Chief, I saw a statement last night that has me puzzled."

"What is it, Will?"

"An advertisement which says that a rise of 10 deg. in the temperature of the feed water represents a saving of 1 per cent. in the coal bill. I can't see how they get that ratio."

"Let's see if we can figure it out, Will. Take your steam tables and see what the total heat in steam is at, say atmospheric pressure."

"It is 1150, Chief."

"What does that 1150 mean?"

"It means that it requires 1150 B.t.u. to convert one pound of water from 32 deg. into steam at atmospheric pressure."

"Right, Will! Then 1 per cent. of the total heat would be what? We just had a little percentage the other day."

"One per cent., or one one-hundredth part of 1150, is 11.5, Chief."

"Then each 11.5 B.t.u. added to the feed water to be made into steam at that pressure would represent 1 per cent., would it not?"

"Sure."

"And 11.5 B.t.u. would raise the temperature of the feed about 11.5 deg., so that for this case a rise in temperature of 11.5 instead of 10 deg. would make a saving of 1 per cent., eh?"

"Yes, Chief, but the total heat is not the same for all pressures and that would make the percentage different, I should think."

"Yes, that is true, so look down the column of pressures and you will see that at about 25 lb. pressure, the total heat is 1160 and at 42 lb. it is 1170 and at 71 lb. it is 1180 and at 123 it is 1190, and when the pressure reaches 227 lb. the total heat is an even 1200 B.t.u. In each you simply point off two places, so in the latter case, of course, 12 deg. per lb. of feed water or 12 B.t.u. would represent 1 per cent. That part of the calculation is easy to understand, is it not, Will?"

"But, Chief, the feed water is seldom freezing cold. Wouldn't that change the figures or percentage?"

"It surely would, and that is what brings the figure down from 11.5 or 12 to about 10 for the ordinary case. For example, to change a pound of water at 32 deg. into steam of 100 lb. pressure takes 1186 B.t.u., but if the feed water were 200 deg., there would already be in it 168 B.t.u. more than in water at 32, so that there would have to be added in the boiler only 1186 — 168 = 1018 B.t.u., and the addition of 10.18 B.t.u. per lb., or the raising of the temperature 10.18 deg., would save 1 per cent. So it is true that ten degrees' difference in the temperature of feed water will make a difference of 1 per cent. when the temperature is around 200 deg., and this is where it ought to be, but as the steam tables are based on the total heat in the steam above 32 deg., the calculation must be from that point as a base. All the heat that the water contains above 32 deg., no matter from what source obtained, must be deducted from the original total heat, then the percentage of the remainder calculated as before, since we are interested only in the heat that has to be put into the water at a given temperature to convert it into steam at the desired pressure. The calculation, however, is just as easy as in the first instance, for all that is necessary is to subtract the amount of heat in the water above 32 deg. from the total heat in the steam as shown by the table at the desired pressure, then point off two places, as before. This will show you at once the number of degrees the water must be heated to equal 1 per cent. of the total heat required under these conditions.

"For example: The sun in heating the water in the pond to 78 deg. has contributed 46 B.t.u. per lb. toward converting it into steam which, for atmospheric steam, would be 4 per cent. of the total heat required. Since, as shown, 11.5 B.t.u. equals 1 per cent., then 46 would be 4 per cent. Then to complete the process there will be required 1150 — 46 = 1104 B.t.u. Pointing off two places as before, 11.04 is 1 per cent. of the remaining heat required, so that 11.04 deg. added to the feed water will save 1 per cent. in B.t.u. Now, suppose a small heater contributed 6 per cent. of the remaining 1104 B.t.u. or added 66¼ deg. to the feed water (1% of 1104 = 11.04 and 6% = 66.24), then 46 + 66 = 112 B.t.u. would have been added to the feed water, leaving 1150 — 112 = 1038. Then suppose an economizer in turn contributed 6 per cent. of the remaining 1038 B.t.u., or added 62.3 deg. to the feed water (1 per cent. of 1038 = 10.38 and 6 per cent. = 62.28 or, for easier calculation, 62.3), then 46 + 66 + 62.3 = 174.3 in all have been added, and the total heat the furnace would have to supply would then be 975.7 B.t.u. and the feed water is entering the boiler at a little over 32 + 174.3 = 206.3 deg.

"To sum up this part of the story: In the first calculation 11.5 deg. rise in temperature of the feed water equaled 1 per cent. of the total heat required; in the second, 11.04 deg. equaled 1 per cent. of the remaining heat required; in the third, 10.38 deg. equaled 1 per cent. of the remaining heat required. So you see there is no fixed amount which equals 1 per cent. under varying conditions, even with a 100 per cent. efficient plant."

"The 1 per cent. for ten degrees is only approximate, then?"

"That's all."

"And the saving is in heat units, not in coal?"

"Yes, but what's the difference? You have to burn coal to get heat units, and if you save half of your heat units you ought to save half of your coal."

"But the saving ought to be greater with a poor outfit than with a good one."

"How so?"

"Why, with a boiler of 80 per cent. efficiency I would only have to develop $\frac{1}{0.80}$ (= 1.25) × 10 = 12.5 B.t.u. in the furnace to put 10 B.t.u. into the steam, while with a boiler of only 50 per cent. efficiency I would have to develop 20 B.t.u. in the furnace for each 10 in the steam. If the feed water is 10 deg. hotter it will save only 12.5 B.t.u. per lb. in the case of the 80 per cent. boiler, but 20 in the case of the 50 per cent. boiler."

"That's right. the heating of the feed water for a poor outfit saves more in heat units and in coal, but the same in per cent."

"How can that be?"

"What is 50 per cent. of 5 pounds?"

"Two and a half pounds."

"What is 50 per cent. of 3 pounds?"

"One and a half pounds."

"But it is 50 per cent. in each case."

"Sure."

"Well. with the 80 per cent. boiler you must develop. as you say. 12.5 B.t.u. in the furnace in order to get 10 into the steam. A saving of one B.t.u., or 10 per cent., in making the steam would make a saving of 1.25 B.t.u. in the furnace. With the 50 per cent. boiler you would have to develop 20 B.t.u. in the furnace to get 10 into the steam, and the saving of 1 B.t.u., or 10 per cent., in making the steam would save 2 B.t.u. in the furnace. Do you get me?"

"Yes."

"For the poor boiler the saving is 2 B.t.u. as against 1.25 for the good boiler."

"Yes."

"But 2 is 10 per cent. of 20 and 1.25 is 10 per cent. of 12.5, so that the percentage of saving is the same in both cases, notwithstanding the actual saving is greater in the case of the less efficient boiler. If you save half your coal when you are using 10 tons a day, it will be more tons than it would if you saved half of only six tons a day, but it will be one-half in both cases.

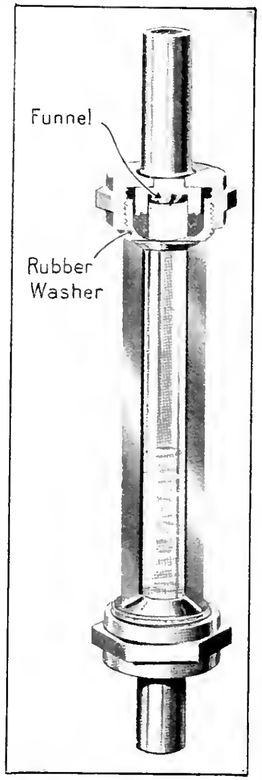
"The next question arises as to how much each B.t.u. is worth in money, which means the cost of the fuel, the labor, etc. If the fuel is cheap the loss, of course, is not so great when heat is wasted, yet the price per ton may be low and still the cost of the B.t.u. it contains or that transferred to the boiler may be high from several causes; low heat value, high cost of labor and unfavorable location being among the things which make it so. Therefore, the calculation must take in the cost of the B.t.u. at different places, by the same course of reasoning. If each B.t.u. in the fuel costs twice as much at one place as at another, then the heat put into the water from some other source is twice as valuable. So you see, Will, only the first general statement can be made which will be universally correct and comprehensive.

"In short the B.t.u. in the water must be considered 100 per cent. It is all there. The efficiency of the B.t.u. in the coal is variable and dependent on the equipment. The cost of the B.t.u. in the coal influences the value of the B.t.u. in the water, and the cost of getting the heat transferred from the coal to the water must be considered for a complete analysis. Does the subject seem clear to you now, Will?"

"Yes, thank you, Chief, and it has given me a better understanding of the necessity of watching the feed-water temperature more closely. I think I'll take more interest in that thermometer on the feed line after what you've told me."

Hill Gage-Glass

The Hill Pump Valve Co., 18 E. Kinzie St., Chicago, Ill., has recently perfected a new gage-glass possessing two distinctive features. It is easy to read and is protected against breakage to an unusual degree. No metal touches the glass. It is held in place by rubber gaskets and is free to expand or contract. Three supporting arms keep the upper and lower connections in alignment and protect the glass against breakage. Should it break, the arms will keep the broken pieces within the inclosure. On the inside the arms are white, so that the glass may be easily read from any angle. To prevent condensation from running down the sides of the glass and making it less transparent, a funnel has been provided and is centered so that the water will drop down through the center of the glass. The rubber gasket and the funnel tend to prevent corrosion at the top of the glass, and the former reduces breakage, which is more or less common when inserting a glass.



Hill Gage-Glass

The Discovery of Oxygen is generally credited to Dr. Joseph Priestly, an English clergyman and scientist. The date, Aug. 1, 1774, is commemorated as the birthday of modern chemistry. At about the same time two others made the same discovery: Scheel, a Swedish apothecary, who called it "fire air"; and Lavoisier, a French chemist, who called it oxygen, meaning "acid former." To Lavoisier is due the credit for the true explanation of combustion.

Development of Switchboards—In the modern electric generating station the protective devices represent the highest class of design and workmanship in the entire installation, while the cost of the switchboard frequently nearly equals that of the plant controlled by it. In the old days, however, says J. Gardner, writing in "Vulcan," few or no protective devices were installed. For instance, in a power station still running there are several 2000-volt 300-kilowatt single-phase generators controlled by open single-pole switches of the simplest type and without even a fuse in circuit; one side of the system is grounded. Everything operates quite satisfactorily until a cable gets grounded or someone makes a mistake; then there is a serious accident. A case of this kind recently occurred. A direct-current generator coupled to a steam engine was being run up in readiness for paralleling with other machines. When the volts were about 100 the attendant closed the main switch of this machine by mistake. Although the fault was discovered immediately, the rush of current into the machine pulled the armature winding partly round the core, and some of the commutator segments were nearly forced out of the V rings. The driving pins in the armature were sheared off and the insulation of the core was damaged. The armature had to be entirely rewound and the commutator rebuilt.

JUST FOR FUN

Failed to Recognize a Thermometer

In our plant we have both steam and hot-water boilers. The chief engineer hired a fireman recently, who had had an engineer's license for over fifteen years and who knew all (?) about engines and boilers. One day the Chief asked me to see if the water was hot enough and to look at the fire, as the demand was heavy. I looked and said, "Yes, it's 160."

After that the fireman, when asked how the fire was, would say, "Fine! I have 160 lb. on it," never realizing that instead of 160 lb. of steam he had 160 deg. It was about three weeks before he "caught on" that it was a hot-water boiler.—*Antoinette Vonasek, New York City.*

"In the Good Old Summer Time"

The retreat from the firing line.

(*From the New York "World"*)

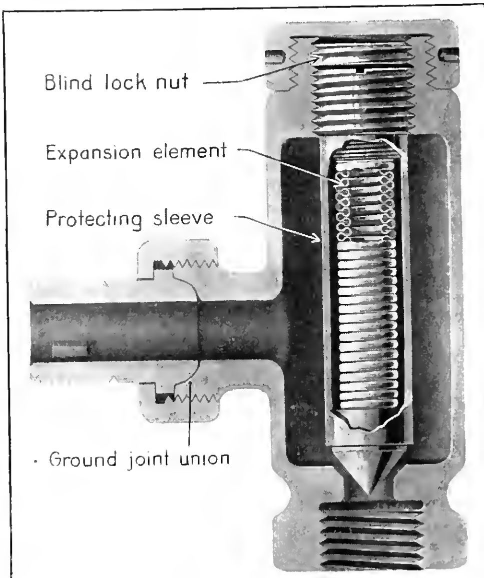
When the Wind Fails

A windmill for pumping water from a mine 60 ft. deep, recently installed and having a wheel mounted on a tower 60 ft. high on the bank of the mine, was an object of interest. Beside the railroad track the section gang during the noon meal discussed the unreliability of power that was available only when the wind was blowing.

The typical section boss, a middle-aged man, had said nothing for some time, but finally he could stand it no longer and he broke in with: "You fellows have bright ideas. Do you think these people are going to wait for wind when they have water to pump? See those cranks, arms and bevel gears. They can put wind on those vanes any time that they have a mind to." This ended the discussion, as no subordinate dared to question the knowledge of his superior.—*T. H. Reardon, Pittsfield, Mass.*

Winn Expansion Trap

The Winn trap shown in section in the accompanying illustration is designed for use on vacuum vapor and modulation systems of heating. It consists of an outer casing made entirely of brass, the valve seat forming an integral part of the casing. A ground-joint union tail piece attaches the trap to the heating unit. In the casing an expansion element, consisting of a seamless corrugated bronze tube which is filled with an expansion liquid, is inserted. The valve head is attached to the tube, and when steam comes in contact with the latter, the liquid



Details of the Winn Expansion Trap

inside expands and pushes the valve head to its seat. As soon as water collects around the tube the liquid contracts and the valve opens, permitting the water to pass through into the return line. A long sleeve guides the valve head to its seat and protects the corrugated element against scale and dirt.

The Winn trap is a modification of the "Welo" trap, which has been on the European market for many years. It is now being built in the United States by the Detroit Steam Specialty Co., Kerr Building, Detroit, Mich.

One of the Effects of Superheat—Superheating steam increases its volume a different percentage for different pressures and temperatures. For example: Steam at 100 lb. pressure superheated 100 deg. expands approximately 16 per cent., while 200 deg. increases its volume 31 per cent., or 15 per cent. for 100 deg., and 300 deg., 45 per cent., or 14 per cent. for 100 deg. For any desired case see the steam tables giving the specific volume of saturated steam, subtract this from the specific volume for the degree of superheat, divide by the specific volume of the saturated steam, and the result will be the percentage of increase in volume. (The same process gives the percentage difference in volume between two different degrees of superheat.) The amount of work steam of a given pressure will do is very nearly in direct proportion to its volume, hence one of the advantages of superheating.

Initial and Operating Costs of Refrigeration Plants

By Robert P. Kehoe

As the figures given by manufacturers to represent first cost, cost of operation, upkeep, etc., are often incomplete, the following tables will be found useful by operators and owners interested in refrigerating and ice-making plants of comparatively small capacity.

Table 1 refers to refrigerating plants. No particular application has been considered and the data may be used for any of the branches of refrigeration, such as general cold storage, markets, hotels, apartment houses, water-cooling plants, fur storage, drygoods stores, and hospitals.

The estimated first costs are necessarily approximate. A refrigerating equipment for a hotel will cost more than a refrigerating plant used solely for cooling water. Again, the same size plant in one hotel may cost more than in another. The figures are a good average, and the comparison between the costs of plants with different drive is quite correct.

Those who now operate plants and know what their equipment cost can use the table to advantage in adding or deducting to the same extent as indicated in the table to determine the difference in cost of other methods of drive. Then by applying the actual costs of labor and fuel, which are known, in the same manner, it may be ascertained how economically each plant is performing and if improvement is possible.

Refrigerating plants of from ten to twenty-five tons' daily capacity are seldom operated by men engaged to do nothing else, but usually by men required for operating other machinery. This has been considered in the table. The figures may be easily corrected to suit local conditions, and the price of fuel also regulated to correspond. The table represents a fair average.

The 60 per cent. yearly load factor assumed should be close to actual conditions in the majority of plants. It will be noted that the labor charge has been carried through the whole year. The 10 per cent. added for depreciation and repairs can be divided about half and half. A 5 per cent. yearly depreciation means complete renewal in fifteen years if the 5 per cent. is calculated as a sinking fund; 5 per cent. yearly for repairs and incidentals should be ample. No building has been taken into consideration because small refrigerating plants are usually located in some part of an existing building.

The advantage of making calculations of operating costs on a yearly basis cannot be doubted. In fact, the daily operating expense alone is misleading, particularly when the yearly load factor is low and a comparatively short period of operation must bear the depreciation and upkeep expense for the year.

The total cost per ton of refrigeration per day is interesting when compared to the cost of using ice for the same purpose. Ice is seldom delivered for less than \$2.50 to \$3 per ton, even in large quantities, and often the price is \$3 to \$4. The table proves that much saving can be accomplished by the refrigerating plant, without considering greater convenience, elimination of slop from melting ice and better preservation of perishable goods under lower temperatures.

TABLE 1 COMPARISON OF INITIAL INVESTMENT, DAILY AND YEARLY COSTS OF OPERATION OF REFRIGERATING PLANTS, WITH DIFFERENT KINDS OF MOTIVE POWER

Refrigerating capacity in tons per day of 24 hours..	10			15			20			25		
Kind of Power	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine	Steam	Electric Motor	Oil Engine
Investment for complete mechanical equipment of refrigerating plant....	$5000 00	$4500 00	$5300.00	$7000 00	$6400.00	$7400.00	$8000.00	$7300 00	$8400 00	$9200.00	$8400.00	$9500.00
Daily operating expense: Labor during night and day (assuming that engineers, etc., are also required for other purposes)	2 00	1 50	1 50	3 00	2 00	2 00	3 50	2.50	2.50	4.00	3.00	3.00
Fuel: Coal @ \$3.50 per ton; oil @ 3½c. per gal; current @ 2c. per kw. hour....	3 50	4 80	1 50	4 75	7.20	1.80	6 00	9 60	2 20	7.00	12.00	2.50
Ammonia, oil, waste and supplies	0 75	0 75	0 75	1 00	1 00	1 00	1 25	1 25	1 25	1 50	1.50	1.50
Net operating expense per day..	$6 25	$7 05	$3 75	$8 75	$10 20	$4 80	$10 75	$13 35	$5.95	$12.50	$16.50	$7.00
Daily operating expense for 60 per cent. of year at full capacity..............	1350 00	1523 00	810 00	1889 00	2204 00	1037 00	2322 00	2884 00	1286 00	2700 00	3564.00	1512.00
Full labor expense for balance of year...... ..	288 00	216 00	216 00	432 00	288 00	288 00	504 00	360 00	360 00	576 00	432.00	432.00
10 per cent. of investment to cover depreciation, repairs and incidentals ..	500 00	450 00	530 00	700 00	640 00	740 00	800 00	730 00	840 00	920.00	840.00	950.00
Total annual expense	$2138 00	$2189 00	$1556 00	$3021.00	$3132 00	$2055 00	$3626 00	$3974 00	$2486 00	$4196.00	$4836.00	$2894.00
Total expense per ton of refrigeration per day	$1 00	$1.00	$0 72	$0 93	$0 96	$0 64	$0 84	$0 92	$0 58	$0.78	$0.89	$0.54

The economy of oil engines as compared with ordinary steam plants and electric motors using central-station current at average rates is quite evident. In the smaller sizes of refrigerating and ice-making plants considered in the tables, the cheaper cost of operation is even more pronounced because small steam plants are not usually economical, while small oil engines perform almost as well as large units.

It may not always be advisable to install an oil engine, on account of local conditions which may favor a steam engine or electric motor. Steam may be required for other purposes. Sometimes the power plant may have to be located in such close quarters that only an electric motor can be used to preserve sanitary conditions. Sometimes it would be inadvisable to place an oil engine or a steam unit in the crowded basement of a hotel, restaurant or hospital where other work is going on and perhaps where foodstuffs are handled. But if the location and requirements do not favor other power, the oil engine will afford a marked saving in the yearly expense.

The table which refers to ice plants is arranged on a basis similar to the table for refrigerating plants. The cost of a special building is included, and the labor is calculated to be used for the ice plant alone. Only half the labor is included during the balance of each year when the plant is shut down or not operated at full capacity. Moreover, special tabulations are given for different yearly load factors. The importance of this factor is indicated by the wide difference in cost of production. For example, the 25-ton oil-engine-driven plant shows a total producing cost of $3.27 per ton when the yearly output is equivalent to three months' full operation, while the same plant producing the equivalent of seven months' full operation reduces the cost per ton to $1.82.

TABLE 2. COMPARISON OF INITIAL INVESTMENT, DAILY AND YEARLY COST OF OPERATION OF ICE PLANTS, WITH DIFFERENT KINDS OF MOTIVE POWER

Capacity in Tons of Ice per Day of 24 Hours	10			15			20			25		
Kind of Power / Type of Plant	Steam, Distilled Water	Electric Motor, Raw Water	Oil Engine, Raw Water	Steam, Distilled Water	Electric Motor, Raw Water	Oil Engine, Raw Water	Steam, Distilled Water	Electric Motor, Raw Water	Oil Engine, Raw Water	Steam, Distilled Water	Electric Motor, Raw Water	Oil Engine, Raw Water
Investment:												
Mechanical equipment complete	$8,500.00	$7,500.00	$8,500.00	$11,500.00	$10,000.00	$11,500.00	$12,500.00	$11,000.00	$12,500.00	$15,000.00	$13,300.00	$15,000.00
Building	3,500.00	3,000.00	3,000.00	4,500.00	4,000.00	4,000.00	5,500.00	5,000.00	5,000.00	6,500.00	6,000.00	6,000.00
Total investment, excluding land)	$12,000.00	$10,500.00	$11,500.00	$16,000.00	$14,000.00	$15,500.00	$18,000.00	$16,000.00	$17,500.00	$21,500.00	$19,300.00	$21,000.00
Daily operating expense:												
One day engineer	3.00	3.00	3.00	3.00	3.00	3.00	$3.50	$3.50	$3.50	$3.50	$3.50	$3.50
One night engineer	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	3.00	3.00	3.00
One day tankman	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
One night tankman	....	....	....	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Extra labor	....	....		....	....		....	....	....	2.00	....	....
Fuel: Coal @ $3.50 per ton; oil @ 3½c. per gal.; current @ 2c. per kw.-hr.	7.00	12.00	2.63	10.00	18.00	3.94	13.00	23.00	5.25	15.50	30.00	6.56
Ammonia, oil, waste and supplies	1.50	1.50	1.50	2.25	2.25	2.25	3.00	3.00	3.00	3.75	3.75	3.75
Net operating expense per day	$16.00	$21.00	$11.63	$21.75	$29.75	$15.69	$26.00	$37.00	$18.25	$31.75	$44.25	$20.81
Yearly Summary—50 Per Cent. Load Factor (6 Months' Full operation)												
Daily operating expense during period of full operation, in dollars	$2,880.00	$3,780.00	$2,094.00	$3,915.00	$5,355.00	$2,825.00	$4,680.00	$6,660.00	$3,285.00	$5,715.00	$7,965.00	$3,746.00
Half of labor expense for balance of year	675.00	675.00	675.00	855.00	855.00	855.00	900.00	900.00	900.00	1,125.00	945.00	945.00
Fixed charges:												
5 per cent. depreciation on cost of equipment	425.00	375.00	425.00	575.00	500.00	575.00	625.00	550.00	625.00	750.00	665.00	750.00
3 per cent. depreciation on building	105.00	90.00	90.00	135.00	120.00	120.00	165.00	150.00	150.00	195.00	180.00	180.00
5 per cent. total investment for repairs, taxes, water and incidentals	600.00	525.00	575.00	800.00	700.00	775.00	900.00	800.00	875.00	1,075.00	965.00	1,050.00
Total annual expense	$4,685.00	$5,445.00	$3,859.00	$6,280.00	$7,530.00	$5,150.00	$7,270.00	$9,060.00	$5,835.00	$8,860.00	$10,720.00	$6,671.00
Number of tons ice produced annually	1,800.00	1,800.00	1,800.00	2,700.00	2,700.00	2,700.00	3,600.00	3,600.00	3,600.00	4,500.00	4,500.00	4,500.00
Total cost per ton of ice per annum	2.60	3.03	2.15	2.33	2.79	1.91	2.02	2.52	1.62	1.97	2.38	1.48
Average selling price to make 10 per cent. on investment	3.26	3.60	2.79	2.93	3.31	2.48	2.52	2.97	2.08	2.45	2.81	1.96
Yearly Summary—42 Per Cent. Load Factor (5 Months' Full Operation)												
Daily operating expense during full operation	$2,400.00	$3,150.00	$1,745.00	$3,262.00	$4,463.00	$2,204.00	$3,900.00	$5,550.00	$2,738.00	$4,763.00	$6,638.00	$3,122.00
Half of labor expense for balance of year	788.00	788.00	788.00	998.00	998.00	998.00	1,050.00	1,050.00	1,050.00	1,313.00	1,103.00	1,103.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$4,318.00	$4,928.00	$3,623.00	$5,770.00	$6,781.00	$4,672.00	$6,640.00	$8,100.00	$5,438.00	$8,096.00	$9,551.00	$6,205.00
Number of tons of ice produced annually	1,500.00	1,500.00	1,500.00	2,250.00	2,250.00	2,250.00	3,000.00	3,000.00	3,000.00	3,750.00	3,750.00	3,750.00
Total cost per ton ice per annum	2.88	3.29	2.42	2.56	3.02	2.06	2.21	2.70	1.81	2.16	2.55	1.70
Average selling price to make 10 per cent	3.68	3.99	3.20	3.27	3.64	2.76	2.81	3.23	2.39	2.73	3.07	2.26
Yearly Summary—33 Per Cent. Load Factor (4 Months' Full Operation)												
Daily operating expense during full operation	$1,920.00	$2,520.00	$1,396.00	$2,610.00	$3,570.00	$1,883.00	$3,120.00	$4,440.00	$2,190.00	$3,810.00	$5,310.00	$2,497.00
Half of labor expense for balance of year	900.00	900.00	900.00	1,140.00	1,140.00	1,140.00	1,200.00	1,200.00	1,200.00	1,500.00	1,260.00	1,260.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$3,950.00	$4,410.00	$3,386.00	$5,260.00	$6,030.00	$4,493.00	$6,010.00	$7,140.00	$5,040.00	$7,330.00	$8,380.00	$5,737.00
Number of tons of ice produced annually	1,200.00	1,200.00	1,200.00	1,800.00	1,800.00	1,800.00	2,400.00	2,400.00	2,400.00	3,000.00	3,000.00	3,000.00
Total cost per ton of ice per annum	3.30	3.68	2.82	2.92	3.35	2.50	2.50	2.98	2.10	2.45	2.79	1.91
Average selling price to make 10 per cent	4.30	4.53	3.78	3.81	4.13	3.31	3.25	3.65	2.83	3.17	3.43	2.61
Yearly Summary—25 Per Cent. Load Factor (3 Months' Full Operation)												
Daily operating expense during full operation	$1,440.00	$1,890.00	$1,047.00	$1,958.00	$2,678.00	$1,412.00	$2,340.00	$3,330.00	$1,643.00	$2,858.00	$3,983.00	$1,873.00
Half of labor expense for balance of year	1,013.00	1,013.00	1,013.00	1,283.00	1,283.00	1,283.00	1,350.00	1,350.00	1,350.00	1,688.00	1,418.00	1,418.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$3,583.00	$3,893.00	$3,150.00	$4,741.00	$5,281.00	$4,165.00	$5,380.00	$6,180.00	$4,640.00	$6,566.00	$7,211.00	$5,271.00
Number of tons of ice produced annually	900.00	900.00	900.00	1,350.00	1,350.00	1,350.00	1,800.00	1,800.00	1,800.00	2,250.00	2,250.00	2,250.00
Total cost per ton ice per annum	4.00	4.33	3.50	3.51	3.91	3.08	3.00	3.43	2.58	2.94	3.18	2.34
Average selling price to make 10 per cent	5.33	5.50	4.76	4.69	4.94	4.23	4.00	4.31	3.55	3.89	4.04	3.27
Yearly Summary—58 Per Cent. Load Factor (7 Months' Full Operation)												
Daily operating expense during full operation	$3,360.00	$4,410.00	$2,442.00	$4,468.00	$6,248.00	$3,295.00	$5,460.00	$7,770.00	$3,833.00	$6,668.00	$9,293.00	$4,370.00
Half of labor expense for balance of year	788.00	788.00	788.00	998.00	998.00	998.00	1,050.00	1,050.00	1,050.00	1,313.00	1,103.00	1,103.00
Fixed charges	1,130.00	990.00	1,090.00	1,510.00	1,320.00	1,470.00	1,690.00	1,500.00	1,650.00	2,020.00	1,810.00	1,980.00
Total annual expense	$5,278.00	$6,188.00	$4,320.00	$6,976.00	$8,566.00	$5,763.00	$8,200.00	$10,320.00	$6,533.00	$10,001.00	$12,206.00	$7,453.00
Number of tons of ice produced annually	2,100.00	2,100.00	2,100.00	3,150.00	3,150.00	3,150.00	4,200.00	4,200.00	4,200.00	5,250.00	5,250.00	5,250.00
Total cost per ton ice per annum	2.51	2.95	2.06	2.21	2.72	1.83	1.95	2.45	1.55	1.90	2.32	1.42
Average selling price to make 10 per cent	3.08	3.45	2.61	2.72	3.16	2.33	2.38	2.83	1.97	2.31	2.69	1.82

Testing and Repairing Pyrometers

By J. Lucas

SYNOPSIS—Describes the fundamental construction of most types of pyrometers, enumerates their faults and shows how their troubles may be corrected. Directions are given for making an accurate pyrometer of material, most of which may be found about the plant.

Types of Pyrometers

The mechanism of most pyrometers on the market is actuated by the expansion and contraction of liquid mercury or metals.

Fig. 1 shows a straight-stem pyrometer, Fig. 2 a high-temperature mercury thermometer, and Fig. 3 a horizontal-face or bake-oven pyrometer. Fig. 4 shows a section of the stem of a straight-stem instrument. A ¾-in. brass pipe acts as a casing for a copper rod *B* welded to a plug *C* screwed into the bottom of the pipe. A collar *D* fastened to the pipe serves as a guide for the rod. The top end of the copper rod is countersunk to receive the end of a lever which transmits the movement of the rod under expansion or contraction to a hand on a dial. The length of the copper rod varies according to the temperature range it is desired to register. Some straight-stem instruments use a copper pipe on the lower end of a brass rod. Other pyrometers have a stem made of a piece of graphite on which is mounted a brass rod, as shown in Fig. 5. The dial, its mechanism and the case are fastened to the end of the pyrometer stem so that the expanding and contracting element is held between two points, one at the lower end of the pipe, the other at the pointer-operating lever. The coefficient of expansion of the stem tube and that of the rod are different, and the rod always expands or contracts more than the pipe, its movement being multiplied by levers in the dial casing.

Fig. 6 shows the interior of a vertical-face instrument. When the rod *A* in the stem expands it transmits its movement to the pivoted pin *B* and to the lever *C*, which carries a rack operating a pinion to which the pointer is attached. The spring *D* fastened to the lever exerts a constant pull on the pivoted pin and holds it in its position.

The dial end of a horizontal-face instrument is shown in Fig. 7. The movement of the expanding element is transmitted by a pivoted pin, as in Fig. 6.

Fig. 8 shows a mercury pyrometer. A heavy, seamless steel tube with a $\frac{1}{16}$-in. hole at *A* holds the mercury. The spring *B* is welded to the cap of the tube, the other end connecting with a lever, as shown. The tube and spring are filled with mercury by holding both upside down; before they are filled the end of the tube is welded and sealed. The movement of the spring is not usually allowed to exceed ¼ in. When it does, mercury is let out of it by unscrewing the stem at *C* until the expansion is ¼ in. One should make sure that the tube is screwed in tight again, as this joint will sometimes leak mercury when it is supposed to be tight.

Pyrometer Troubles

Sometimes the pointer on the dial will move in jumps instead of slowly. This indicates that there are loose joints somewhere. The bottom plug may be loose or dirt may have collected around the guide collar (*D*, Fig. 4), preventing free movement of the rod. When this happens the rod will bend as indicated by the dotted lines (Fig. 4), and of course the instrument cannot indicate correctly. To remedy this take the case off the stem (pipe), unscrew the bottom plug and wash the stem and rod with gasoline. The rod must be straightened before the instrument is reassembled. Now put the stem in a pail or vessel of boiling water for a few minutes and set the pointer on the 212-deg. F. mark. Whenever there is no movement of the pointer for variations in temperature the usual cause is that the pivoted pin has fallen from its bearing.

Troubles Caused by Graphite Rod

The graphite-rod pyrometer is subject to a peculiar trouble. After long service the rod seems to slowly disintegrate, its diameter becoming less and less until its expansion for a given temperature rise is not what the instrument was calibrated for. The remedy, of course, is the use of a new rod of the original diameter and length.

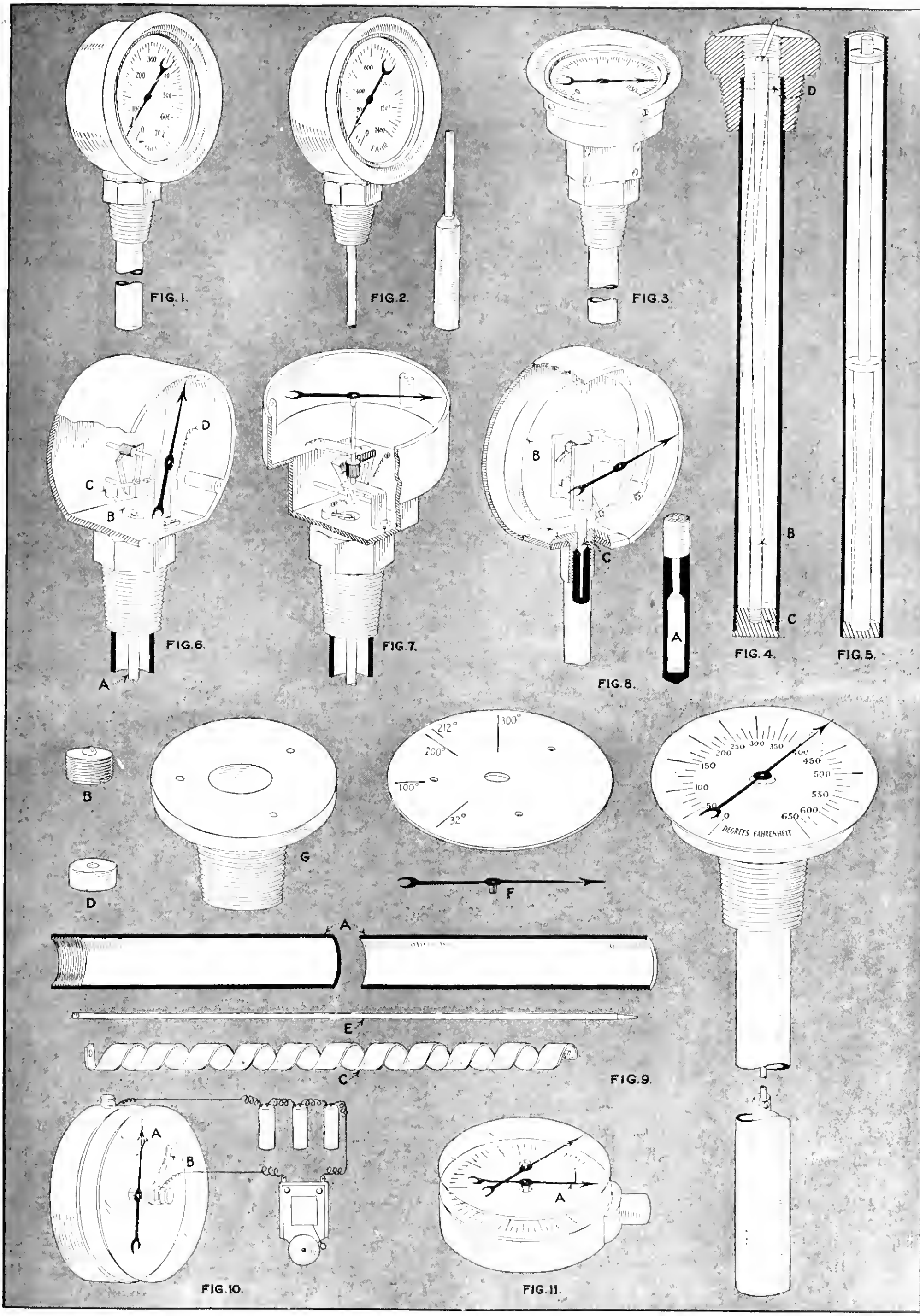
A "Home-Made" Pyrometer

Many plants and shops where a pyrometer is needed only occasionally will find the one described herewith serviceable and accurate. A piece of $\frac{1}{16}$-in. steel pipe *A*, 1 in. diameter and 24 in. long, is threaded inside at one end to receive the plug *B*, and the other end is threaded on the outside to screw into the base of the case. A brass spring strip *C* $\frac{1}{32}$x1¼x30 in. is formed spirally, having ½-in. pitch and ½-in. diameter. This spring will be about 10 in. long. One end is brazed to the plug *B*, and the spring and plug are put into the pipe *A*. The guide-disk *D* is then brazed or soldered to the other end of the pipe. This disk has a $\frac{3}{32}$-in. hole to guide the steel spindle *E*, $\frac{1}{16}$ in. diameter, which should be fastened to the lower end of the spring by a rivet or screw before the spring is put into the pipe. The top end of the spindle should be pointed to permit forcing on a 5-in. hand or pointer *F*. A piece of tin or sheet iron 6 in. diameter is used for the dial. The flange *G* is now screwed into the pipe, the dial fastened, and the pointer laid near-by, ready to be forced on the spindle. The instrument is now ready for calibration.

Pack the stem for its full length in a pail of chopped ice. After about ten minutes force on the pointer, and under and to one side mark 32 deg. F., the freezing point. Next immerse the stem in water kept at 100 deg. F., as indicated by a correct thermometer. When the pointer will move no more make the 100-deg. F. mark on the dial. Next heat the water to 200 deg. and mark the dial. Also, mark it at 212 deg. The stem is next immersed in crude oil heated to 300 deg. F. For the rest of the dial the spaces between 300 and 400, 400 and 500, etc., may be divided off equally up to 650 deg. F., for which range the instrument is well suited.

Pyrometer Alarm

Sometimes it is desired to call the attendant's attention by alarm when a certain temperature has been



INDICATING PYROMETERS AND THEIR MECHANISM. FIG. 9 SHOWS ONE THAT MOST ANY ENGINEER CAN MAKE reached. This may be done by putting on the pointer pin an adjustable piece *A*, Fig. 10, which is held in position by a thumb-nut. A light flat spring is soldered to the pointer and contact poles are fastened to the instrument, as shown. The movable contact piece *B* is set over the desired temperature mark on the dial, and when this is reached the spring on the pointer makes contact, closing the circuit and ringing a bell.

Should it be desired to have the pyrometer indicate the highest point reached after the temperature has fallen, a dummy pointer may be used. This is an ordinary pointer mounted as shown in Fig. 11, and which is free to move so that the indicating pointer may push it around by engaging the projection *A* on the dummy. Usually, the dummy pointer is painted red or white so it can be easily distinguished.

Lining Up Small Turbine Sets

By J. H. Hurley*

The successful operation of any turbo-generator, turbo-pump or turbo-blower set depends so much upon the satisfactory alignment of the complete unit that too much attention cannot be paid to this matter when erecting these machines. The idea that because the unit is on a cast-iron bedplate the latter cannot be sprung is erroneous, as it is easy to twist a bedplate by wedging unevenly or by pulling down holding-down bolts at, say, opposite corners.

Another mistaken idea is that because a machine is fitted with a flexible coupling, alignment between the two ends of the unit is unnecessary. The so-called flexible coupling will take care of a small amount of misalignment and also should eliminate the thrust of one machine being thrown onto the other. In other words, it has the effect of making each end of the machine self-contained, but owing to the high speed at which these machines run it should never be assumed that a flexible coupling will satisfactorily take care of any appreciable misalignment, and the machines should be lined up with a flexible coupling just as accurately as if the coupling were solid.

The rough-and-ready method of lining up with a straight-edge across the two coupling faces, Fig. 1, often

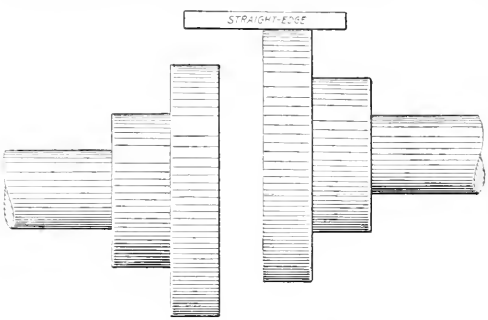


Fig. 1. Lining Up with the Straight-Edge

is satisfactory, but this is only so when the couplings are true in themselves. This condition, however, is often by no means the case and couplings are frequently found to be out of true on their own shaft. To take care of this possibility, therefore, the following method of lining up is suggested, taking into account all the possibilities of untrue couplings in addition to the regular and orthodox method of lining up.

Try out couplings to ascertain if they run true by placing a straight-edge on one half of the coupling, then by the use of a thickness gage, Fig. 2, ascertain the high and low side of one half by rotating one half, then take a mark at 90 deg. from those points and use those

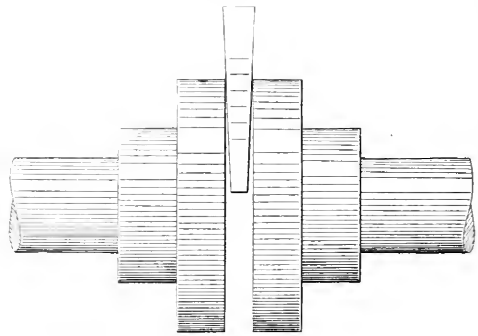


Fig. 2. Application of the Wedge

points exclusively both for horizontal and vertical lines. Then in turn let this half stand still and rotate the opposite half in like manner. Place the straight-edge on both faces at those points until both flanges are flush on the sides, allowing the regular amount on the turbine side, top and bottom, for heat expansion for the generator, boiler-feed pump, circulating pump, blowers or other sets according to their different temperatures when operating.

This same method should be used on the faces of couplings, as it happens sometimes that couplings run out on the faces when they run perfectly true on the sides. In this case a taper wedge may be used to find the high and the low points. Then, when those points are obtained, use such liners as may be required to bring the faces parallel.

It is generally understood that bases are leveled at the works before the sets are bolted down. If this is properly done the sets may be placed for grouting by inserting wedges at all points where it will effect the coupling in the direction required.

Should the set be erected on the job, then follow the usual course by first leveling the base and allowing height enough for substantial grouting, which is usually about ¾ in.; then locate the sets as described.

Always use metal liners or wedges, as wood is apt to shift on account of the dampness of the grouting, with disastrous results. When the grouting is properly set the sets should be checked and the bearings properly

*Mechanical department, the Terry Steam Turbine Co.

washed out before oil is put in. The governor should be worked back and forth to free it and remove rust which may have accumulated while standing.

Many couplings are not drilled to jig and, therefore, the pins will only fit in the holes which are matched. Couplings are generally stamped in a case like this, showing where they should be matched.

When sets are doweled at the works, or if for any reason it is necessary to change liners, the holes should be again reamed when the dowels are taper and should not be driven hard enough to stretch the metal, but tapped slightly until the tapping becomes solid.

All flanges should be brought to the turbine or pump square, and when rigid no soft gasket should be used to draw the sets out of line and shear the dowels.

In lining up generators, place chalk marks at one point on each end of the armature; all aligning should be done from these marks with the use of a wedge or a feeler, as taking several points on the armature would not be correct on account of the high spots in the banding. In all cases make sure that the core of the armature and the core of the polepieces are equally centered with each other so as not to cause a thrust on the turbine bearing. The core of the armature is always longer than the polepieces.

It is hard to decide how far out couplings can be allowed to be and still work satisfactorily, but the writer would say that if they are out more than $^1/_{64}$ in. any way, special care should be exercised in starting the machine, and if it does not run smoothly enough this should be reported, with a special remark about the couplings being out of the true, so that the matter may be taken up with the coupling makers.

The mixture for grouting in a machine should be half pure cement and half sand. After grouting, the machine should be allowed to set for 18 hours. Foundation bolts should be left loose or screwed down by hand until after the concrete is set, when they may be tightened firmly.

In lining up, as previously mentioned, use iron wedges only. They should be placed under the spot where the weight comes and as near the foundation bolts as possible.

Cold-Air Intake Duct for Air Compressors

By R. S. Bayard

SYNOPSIS—Shows by simple explanations and plain calculations how an intake duct drawing air at atmospheric instead of room temperature lowers the average cost of compressed air.

It has often been observed that the output of an air compressor is greater in winter than in summer; that is, it seems that a machine which has had to "hustle" to furnish air in summer, may be able to maintain the required pressure at a reduced speed during the winter. The reason for this is often asked, so an explanation will be of interest.

This difference can be observed only when the compressor takes its air through a duct leading from the outside air, because it is due to the effect of the difference of air temperature between the compressor intake and the place where the air is used or conveyed through.

Imagine a cylinder having a perfectly tight piston held, we will say at midstroke, and the half-cylinder full of air at atmospheric pressure and at a temperature of 60 deg. F. The atmospheric pressure is, with 30-in. barometer, 14.7 lb. per sq.in. With the piston held rigidly and leak-tight, assume that we can heat the cylinder so that the air inside will become 100 deg. F. This will cause the air to expand and try to occupy more space, but if the piston will not move the air cannot expand, so it will increase in pressure. Mathematically, the pressure produced in this way will be

$$14.7 \times \frac{100 + 460}{60 + 460} = 14.7 \times \frac{560}{520} = 15.84 \textit{ lb. per sq.in.}$$

That is, the new pressure, absolute, will be equal to the first pressure, absolute, multiplied by the ratio of the absolute temperatures. (The absolute temperature is found by adding 460 to the Fahrenheit temperature, as done above.)

If, in the cylinder we are considering, the piston is allowed to move as the air expands and if it has no friction, so that the air pressure does not increase, the final volume will be larger than the original volume in the ratio of the absolute temperatures. If the original volume was, say 10 cu.ft., the final volume after the piston has moved due to increase of air temperature will be

$$10 \times \frac{100 + 460}{60 + 460} = 10 \times \frac{560}{520} = 10.77 \textit{ cu.ft.}$$

At the usual room temperatures (about 520 deg. F. absolute) the increase of volume is, roughly, 1 per cent. for every 5-deg. F. increase of temperature.

Let us see how the foregoing applies to a compressor plant. Irrespective of the outside temperature, the air in the shop pipe lines will be nearly at the temperature of the room by the time it reaches the tool. Suppose in winter this temperature averages 68 deg F. and that the air finally reaches the tool at this temperature. If the compressor takes in 1000 cu.ft. of free air (air at atmospheric temperature and pressure) directly from the room, it will also deliver 1000 cu.ft. of free air at the tool, because the final temperature is the same as that at which it entered the compressor.

In summer the same conditions apply as long as the compressor takes its air from the same room in which the compressed air is used; but if the compressor is provided with an intake duct leading from the outside air, the results will be quite different. First, consider the winter condition. Suppose the shop temperature averages 68 deg. F. and the outside air 30 deg. F. If the air is used at 68 deg., its volume will be considerably greater than the volume taken into the compressor from the outside air at 30 deg. If it requires 1000 cu.ft. of free air per minute at shop temperature to run the tools, the compressor will have to take in only

$$1000 \times \frac{30 + 460}{68 + 460} = 1000 + \frac{490}{528} = 929 \textit{ cu.ft.}$$

which is a saving of over 7 per cent. in air capacity, speed and horsepower. In summer, when the outside temperature is practically the same as the temperature indoors, there would be no saving by using the intake duct, except, as is often the case, when the compressor takes its air supply directly from the hot engine room. Thus, it is seen that the compressor would run at a speed about 7 per cent. lower in winter than in summer. The colder the climate, the more pronounced this effect would become.

An actual case where the application of an intake duct to a compressor represented an appreciable saving recently came to the writer's attention. An air compressor furnishing an average of 2500 cu.ft. of free air per minute to a machine shop took its supply from the basement of the engine room, where all the year round the air, heated by a network of steam pipes, averaged 95 deg. F., while the shop averaged 70 deg. F. During the winter months the outside air averaged 32 deg. F., and in summer 70 deg.

Based upon the average consumption of 2500 cu.ft. per min. for 10 hr. a day, the air used amounted to an average of

$$2500 \times 60 \times 10 = 1,500,000 \textit{ cu.ft.}$$

per day at the shop end.

As the compressor-intake temperature averaged 95 deg. F., the compressor was obliged to run fast enough to take in

$$1,500,000 \times \frac{95 + 460}{70 + 460} = 1,500,000 \times \frac{555}{530}$$
$$= 1,570,500 \textit{ cu.ft.}$$

of engine-room air per day.

The cost of compressed air in this plant was found to be 2.8c. per 1000 cu.ft. at the compressor. Thus the cost of furnishing air to the shop was

$$\frac{1,570,500}{1000} \times 0.028 = \$43.97 \textit{ per day}$$

By putting in an intake duct and furnishing air to the compressor at 30 deg. F. in winter, the compressor could have run slower and would have had to take in only

$$1,500,000 \times \frac{30 + 460}{70 + 460} = 1,500,000 \times \frac{490}{530}$$
$$= 1,387,000 \textit{ cu.ft. per day}$$

At a cost of 2.8c. per 1000 cu.ft. at the compressor intake, the average cost of air for the plant during winter would then be

$$\frac{1,387,000}{1000} \times 0.028 = \$38.84 \textit{ per day}$$

During the summer, when the outside and inside temperatures both averaged 70 deg. F., the compressor would take in only the amount used in the shop, or 1,500,000 cu.ft., which at the cost of 2.8c. per 1000 cu.ft. at compressor intake would be

$$\frac{1,500,000}{1000} \times 0.028 = \$42 \textit{ per day}$$

With the intake duct in use we then have a daily cost for air of $38.84 for winter and $42 for summer. The average for the year may then be taken at $40.42 per day, as against $43.96 with the compressor taking air from the engine-room basement.

During a working year of 300 days, the annual cost for air would then compare:

Without intake duct..................	$43.96 × 300 = $13,188
With intake duct.....................	40.42 × 300 = 12,126
Giving a net saving with the duct of............	$1,062

Capitalized at 10 per cent., this would justify installing an intake duct costing $10,620. As this figure approaches more nearly the cost of the compressor than it does the cost of the duct, the conclusion is obvious.

Incidentally, the saving of $1062 per year amounts to more than 8 per cent. of the yearly cost for air. It certainly looks worth while to install an air-intake duct under such conditions.

The Planetary Motion

The planetary motion devised and used by Watt to convert reciprocating into rotary motion is of interest, first because it was brought into use to circumvent a patent previously obtained by Wasborough on the simple crank for the same purpose. The other interesting feature is a condition where two gear wheels of the same diameter engage, but one makes two revolutions for each one revolution of the other. This may be easily tried out, or demonstrated, by using two coins with the edges sharply milled. Hold one of them stationary with the head up, or stick it fast with a little mucilage. Place the other with the head up directly in a vertical line above the head of the first. Now rotate the upper coin to the right around the fixed coin. It will be seen that by the time the former has reached the half revolution or the point directly below the fixed coin it will have turned one complete revolution, standing head up again. Another complete revolution will be accomplished by the time it reaches its original position. It will therefore have made two complete revolutions while engaged with a stationary coin of the same size.

It is obvious then, that if the coin being rotated were held head up all the way around, and the other coin made to rotate as on its center the latter would have to make two complete revolutions by the time the two coins had reached their original relative positions. One revolution is due to the crank motion and the other, to tooth engagement. This is proved by using a traveling gear twice the circumference of the shaft gear, which will produce a 3 to 1 ratio by reason of doubling the larger gear, instead of what might be expected—a 4 to 1.

Examples of the modern application of the planetary gear in the opposite way may be found in some geared chain hoists and also in some automobile transmission gears for slow speed.

Lloyds Safety-Valve Rules require that two safety valves be fitted to each boiler, the combined area of which shall equal at least ½ sq.in. for each square foot of grate area and the accumulation of pressure shall not exceed 10 per cent. of the working pressure. Each valve is to be so made that no extra load can be put on while under steam pressure.

Editorials

Michigan Is in Line

Michigan made a gallant fight for the adoption of the boiler code of the American Society of Mechanical Engineers during the session of the legislature recently closed. A bill (Senate Bill No. 234, File No. 299) provided for the appointment of a board of boiler rules to formulate rules as near in conformity with the A. S. M. E. code as possible. It passed the Senate without a dissenting vote. The bill was then referred to the Committee on State Affairs in the House and two hearings were granted, but those in charge of the bill were unable to secure the reporting of it out of the committee. The belief is general that if this bill had been reported out it would have been enacted into law with little opposition.

It is believed that at the next session of the legislature the A. S. M. E. code will be adopted by the state and a system of license regulations put in force.

It was discovered during the fight for the passage of this bill that opposition on the part of the thresher engine interests and the threshermen's organizations is weakening and coming to a realization that modern boiler practice and means for public safety must prevail and are a good investment.

This is the first time in the history of Michigan that a bill relating to boiler matters or engineers has passed either house of the legislature without a dissenting vote.

Michigan is in line. Let her move up to the window and receive her code.

The National Electrical Safety Code

The two principal sources of hazard to life around a power plant are the boilers and the electrical equipment, particularly where high voltages are employed. Just as safety in the boiler room depends upon the construction of the boilers and their intelligent operation, that in the electrical end of the station depends upon the proper installation of the electrical equipment and the care in handling it. The excellent work of the Boiler Code Committee of the American Society of Mechanical Engineers in preparing its recent boiler code, has been emulated by the Bureau of Standards, which has been at work for nearly two years on an electrical safety code. It is particularly fitting that this work should have been undertaken by this bureau, devoted in its scope to scientific and engineering problems and in a position to approach the subject with an open mind. While the bureau has employed experts especially for this work, it has in no way attempted to force its own opinions on the public, but instead has endeavored to learn the views of various electrical companies and, through conferences and sifting of these views, to arrive at a set of rules which will represent the best practice.

The rules are divided into four parts, the first three dealing respectively with the installation and maintenance of electrical supply stations and equipment, electrical supply and signal lines, and electrical utilization equipment; the fourth covers rules for the operation of electrical equipment as concerns both the employer and the employee. Part 4,* which is printed as a separate bulletin, was first published last August in a tentative form and was widely circulated for comment and criticism. It has now been revised in accordance with a number of suggestions and, in conjunction with Parts 1, 2 and 3, is being circulated for further criticism before final revision.

Lack of space prevents our reprinting the rules, but we would urge those readers who are interested to obtain copies from the Superintendent of Documents at Washington, and send in such suggestions as may seem advisable.

While the Bureau of Standards has no direct power to enforce the observance of such rules, it is believed that most electrical companies and even private plants will find it advantageous to adopt them. Moreover, it will form a set of uniform rules, which public-service commissions or municipalities may find it convenient to enforce.

Taking Charge of a Larger Plant

To "make good" in the new sphere of duty is the honest ambition of every right-minded engineer who is promoted to larger responsibilities. Not always, however, does he find his hopes realized under the changed conditions. Failure to do so may be due to many causes.

Causes beyond the engineer's control cannot be helped. Vicissitudes such as the collapse of a factory business through changed economic conditions, the sale of an industrial plant by the owners to others who prefer to discontinue power production locally because of representation on central-station directorates, or the maladministration of a property through nepotism will discourage any but the trained operator, who knows that in the long run there is sure to be a market for his services. It is more important to consider those factors in service over which the engineer may maintain mastery—those policies which lead to success when properly directed and applied in the new field of usefulness.

On taking over a larger installation the temptation arises to emphasize the weak spots left by one's predecessor and to make a clean sweep of methods which at first appear open to criticism. It is wiser to make haste slowly. The sharpest possible analysis is commendable, but little is lost by taking sufficient time to get one's bearings.

No installation looks the same from within as it does from the outside, and to make a brief inspection of a plant as a possible chief engineer, and then later to go over the installation as its responsible executive are two very different things. No two plants are exactly alike, and even if similar in makeup, will not run in exactly

*See "Power," Dec. 8, 1914.

the same way. The engineer who takes time to learn the personal abilities of his new subordinates and the strong and the weak features of the equipment, individually and collectively, is wise. Let him avoid attempting to reform the whole institution the first week, and by the second or third week he may find it possible to begin to effect some real economies through the coöperation of those under him. While a glaring instance of preventable waste should not be allowed to continue even for a week, it pays to let the old staff discover that the new chief is willing to learn, that he is glad to receive the help of those more familiar than he with the local equipment and load situation, and that he is determined not to act on snap judgment to impress the "boss" with his instant ability to cut costs and make a new record.

An exceptional man may take over a new job of this kind and almost immediately inaugurate an efficiency policy which revolutionizes practice within the station. Such an overturn may be accompanied by a substantial crop of recommendations for discharge, without waiting to find out if the men most familiar with the routine work cannot gradually be brought to work in harmony with the new program. It takes time to find out what those already on the ground can do, and a plant may fail to do its best work for many reasons other than incompetency of the force. It is nearly as important for a new chief engineer promoted from within to introduce his executive ideas moderately. Where a subordinate engineer is not available to promote, the new chief needs insight and tact to get the best from his predecessor's force.

A contented staff has more to do with economical operation than some realize, and whether an engineer takes charge from within or from without, a probationary receptive period is an effectual means of getting acclimated to his new responsibilities.

Recognizing Abnormal Conditions

The ability promptly to detect abnormal conditions in plant operation is most valuable to the engineer. Nothing so clearly denotes the expert as immediate appreciation of the existence and cause of any unusual sound. The same is true with respect to scrutiny of the log sheet and to the study of test data.

While many sources of inefficient operation are soundless, cultivation of a keen sense of hearing is worth much to the engineer. With high-speed machinery, even very slight departures from the normal tend to become magnified. Every plant has in a measure its own sound characteristics, due to the sort of load it carries and to the peculiar combinations and sizes of main and auxiliary units in service. From long experience most engineers will sense abnormalities in sound almost subconsciously, but a new man will need to make a special effort to develop this faculty as quickly as possible. Things happen pretty fast when an unusual condition becomes cumulative, with modern turbine and high-powered auxiliary equipment; the value of machinery under the control of the engineer today runs to figures far in excess of a decade ago; and the ability to see ahead and to catch the drift of sounds which the untrained visitor would never notice is very important.

When examining operating and test records, a similar skill in instantly "spotting" departures from the normal is of great advantage. It takes practice to scan tabular data rapidly without losing their significance. The starting point is to know what to expect in a routine way, and this can be acquired by continued study and observation. Roughly, each plant may be said to have a set of "constants" of its own. That is, the temperature of the feed water will run between such and such limits when every day's record of coal consumption per kilowatt hour keeps down to the average minimum consistent with the local conditions; the variations in steam will follow a well-defined cycle, if this is varied purposely, or will hold close to a predetermined zone above and below a fixed average so long as things go as they should. Seasonal variations will be noted in the temperature of intake and discharge water.

It is the engineer's task to maintain normal conditions of service and instruments help in this work, but perhaps too much reliance is placed on automatic charts at times. The really professional understanding of one's plant is the kind that combines the keen ear and the microscopic eye with a continuous apprehension of a considerable number of physical data which set a standard for every departure from efficient operation. In other words, when the readings of instruments depart from the normal by a certain differential, when test sheets contain figures that jump out of the routine range for a little while, the expert engineer notes them at once and if possible acts promptly and reduces preventable losses.

Intense personal interest in an installation leads to skill in diagnosing the approach of abnormal conditions through knowledge of what seem trifles to the man of mediocre ability or to the layman. The result is a reduced maintenance expenditure and a better record for service continuity, to say nothing of an almost inevitable improvement in operating economy.

The Federal Government inspects the locomotive which draws your train, and no steamer can carry passengers without a certificate from the Federal inspector that its boilers have been inspected and its engineers examined and found safe and competent. The Federal Government also requires the stationary boilers in the District of Columbia to be inspected and requires a competent attendant for them, but only four out of forty state governments are equally solicitous for the safety of their citizens. The people are protected when they travel, because the Federal Government can do it, but not when they stay at home, because the state government will not.

The troubles of the engineer are many and sometimes unique. One of our good friends up along the Hudson River finds so much moisture in the air used for forced draft that in winter ice accumulates on the under side of the grate. Sometimes, especially when the fire is about four hours old, ice so plugs the air spaces in the grate that it becomes necessary to put a steam hose in the ash-pit and melt it so as to pass enough air to keep up the required rate of combustion.

Our contemporary, *The Electrical Review* of London, "cannot approve of all methods adopted by American consuls" in stimulating trade activity with France. Why should they?

Correspondence

Gas Explosions in Boiler Furnaces

In your issue of Apr. 20 I read the interesting communication by L. A. De Blois, concerning a gas explosion in a boiler furnace. The three correspondents appear to be at a loss to explain the formation of an explosive mixture, or, in other words, the entrance of a sufficient amount of air into the formed carbon monoxide under the condition described; that is, with the fire-door closed, the tuyeres blocked by a clinker and the damper wide open. It seems to me that the formation of an explosive mixture under these conditions is a very natural occurrence.

Carbon monoxide is somewhat lighter than air, and on account of the higher temperature in this case it is considerably lighter than the outside air. The open stack with the closed furnace, therefore, represents a vessel having a lighter fluid at the bottom and a heavier one on the top. These two fluids, if not in motion, are in unstable equilibrium, and it is only natural that a slow flow of the lighter gas toward the top on one side of the stack and a corresponding return flow of the heavier air on the other side of the stack would take place. I believe that the sketch will make this clear.

The moment the fireman broke off the clinker and thereby opened the discharge from the fan, rapid combustion was started, with a consequent development of high temperature, probably projecting a flame into the combustible mixture. This started the explosion because the time intervening between the opening of the fire-door and the breaking off of the clinker was not sufficient to remove this explosive mixture from the furnace.

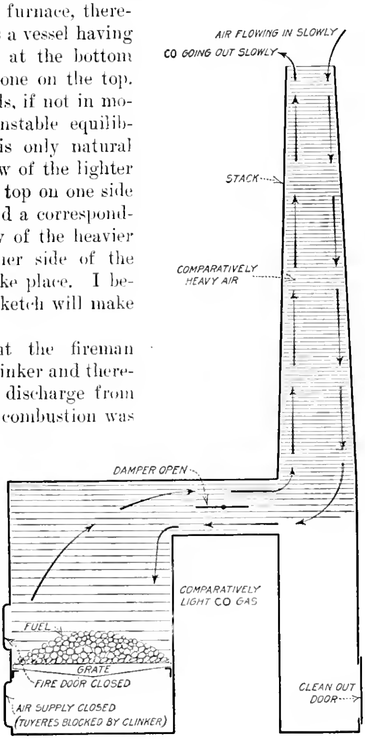


Fig. 1. How Air May Have Entered Furnace and Caused Explosion

It seems to me that a reliable arrangement for preventing this occurrence could be made. If the conditions of the furnace, its operation and the fuel used are such as to permit a constant admission of a small amount of air above the fire, an opening should be provided in the fire-door and it should be made impossible to close this opening. In this case, even if the tuyeres were completely blocked, the constant, if slight, draft would remove any carbon monoxide that might be formed.

If, however, the existing conditions do not permit this sort of an arrangement without destroying the efficient operation of the furnace, a bypass may be provided in the air supply, branching off between the blower and the tuyeres and entering the furnace above the fire. This bypass should have in it an unbalanced damper which is normally closed but which opens when the pressure in the air-supply pipe rises on account of the tuyeres being stopped up. This damper (or virtually, check valve) could easily be provided with an indicator on the outside by which the fireman's attention would be called to the fact that the tuyeres have become clogged (see Fig. 2).

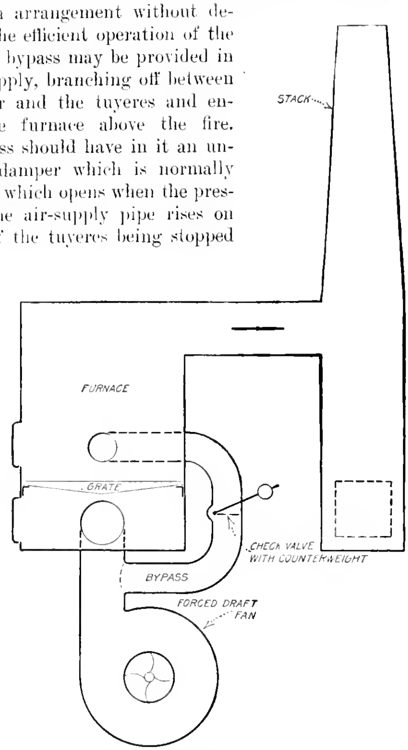


Fig. 2. Bypass around Grate

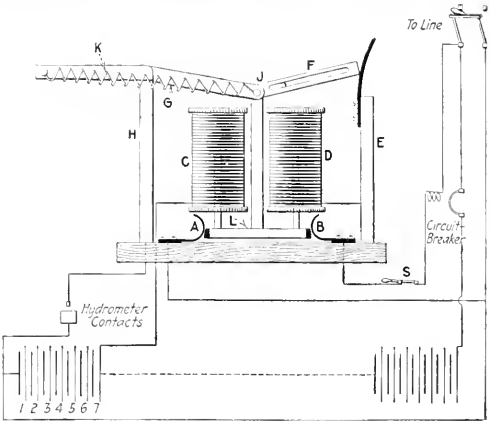
This analysis is based only on the information which I can gather from the communications as I found them in Power. Should my understanding of the case be incorrect, I would appreciate a word from Mr. De Blois, to clear the situation in my mind.

Robert Cramer.

Chicago, Ill.

Low-Gravity Cutout for Storage Battery

The battery in question was rated at 50 amp. at an 8-hr. rate and supplied current for lighting and for a few small motors from 6 p.m. until 7 a.m. It had been badly overloaded at times, and despite repeated warnings to various people around the institution, the overloads would recur all too frequently. Finally, it was decided that something more effective than warnings was necessary. After considering various plans, it was decided to install a circuit-breaker which would be tripped when the recording hydrometer dropped to a certain point. This hydrometer was already equipped with a contact on the pen arm, which dipped into an adjustable mercury cup, so that this part of the job was very simple. It was necessary to construct a relay to close the trip coil circuit and install a circuit-breaker. The sketch shows the relay and wiring diagram.



Wiring of Automatic Cutout

When the hydrometer reaches the lowest point desirable, it closes the circuit through solenoids *C* and *D* and part of the battery. It was best that this circuit should be broken as soon as it had accomplished its purpose so as not to further drain the cells. This was provided for as follows:

Current passes from cell No. 7 to coils *C* and *D*, thence to post *E* and the flat spring attached to it, through *F* and *G* and down post *H*, via the hydrometer to cell No. 1. As soon as current flows, *C* and *D* are energized and *L* is lifted and also the rod which is attached to it. This throws the joint *J* upward, and the coiled spring pulls it back, drawing *F* out of contact with *E* and breaking the circuit. Once *L* has been pulled up, it cannot fall, because the spring contacts *A* and *B* are so formed and adjusted as to prevent it. As soon as *L* bridges *A* and *B*, line current flows through the coil of the circuit-breaker and trips that device, thus opening the battery circuit.

If anyone should gain entrance to the engine room and attempt to reset the breaker, the latter would immediately open again, because by the closing of the breaker its trip coil would again be energized. Furthermore, as the relay is under lock and key, no one could reset it except the engineer having the key.

It remains to relate that the principal offender was the first to be caught. When he had carelessly pulled the battery down and the circuit-breaker had opened, he found himself in inky darkness.

William E. Dixon.

Cambridge, Mass.

Crankpin Failure

The photograph, Fig. 1, is of a crankpin that failed recently on one of our 24x36 first-motion hoisting engines. When the pin failed both guides broke, the rear cylinder head was broken out by the piston, and the piston and piston rod were ruined. The engineer shut the throttle the instant the accident happened and threw on the brake, thus stopping the cages where they were and preventing a more serious damage. Fig. 2 gives the dimensions of the pin and shows where the break occurred. This sort of failure is what is called a fracture in detail.

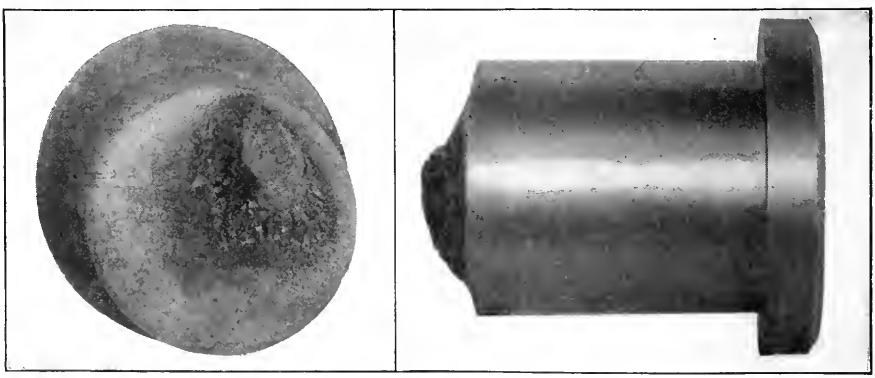


Fig. 1. Two Views of Broken Crankpin

It was not due to any flaw in the material, nor does it seem possible that the pin was too small. The maximum steam pressure carried is 120 lb., and with this pressure on the 24-in. piston the total load on the pin would be less than 55,000 lb. The 4½-in. pin, the cross-sectional area of which is $15\frac{7}{10}$ sq.in., should be large enough to carry the load with a large factor of safety. Of course, if there was any slack rope the starting load would be greatly increased, but the ropes are always kept closely adjusted. No doubt the trouble was due to a fault in the design of the pin. It will be seen that the corners on both sides of the 7/8-in. collar next to the crank disk are perfectly sharp, with no fillets whatever. These were the weak points at which the fracture could start. The 7/8-in. collar mentioned was a part of the crankpin. Probably it would have been better if this had been a

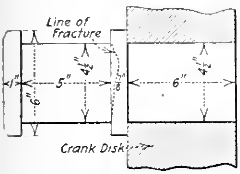


FIG. 2. ORIGINAL DESIGN, FAILED

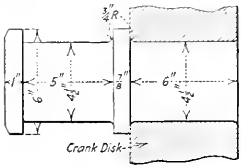


FIG. 3. NEW DESIGN

separate collar shrunk on at the proper place, thereby eliminating the sharp corners. We have three hoists of the same size in service, and considerable trouble has been experienced in the past with crankpin failures. Occasionally, the wrecks have been rather serious. More than once the whole cylinder was wrecked and had to be replaced. Various grades of steel pins have been experimented with, but the results were practically the same. So it was decided to change the design of the pin. Fig. 3 *B* shows the new design adopted. It is thought that the 3/4-in. radius fillets on each side of the collar will stop the trouble. However, these new pins have not been in service long enough to prove anything yet.

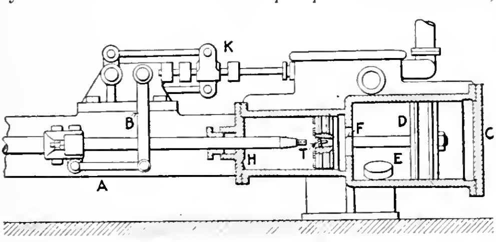
I would like to know whether any of the readers of POWER have had similar experiences, and if so what steps they have taken to remedy the trouble.

F. F. JORGENSEN.

Gillespie, Ill.

Pump Would Not Run

When a duplex tandem compound pump failed to start it was at first thought that the steam valve had shifted, but links *A* were disconnected and the valves operated by lever *B*. One side of the pump made full strokes,



CONDITIONS INSIDE OF PUMP

but the other side moved only a few inches in the center of its travel and struck something solid.

Head *C* and the low-pressure piston *D* were removed, and in the bottom of the cylinder was found the nut from the end of the high-pressure rod, and the large disk *E* which screws in the center of the wall *F* between the two cylinders.

Head *H* was removed and it was found that a follower bolt *T* had dropped out of the high-pressure piston and had worn the cylinder head about half through, at *H*. This bolt was found wedged in the hole in the center of the high-pressure piston, as shown. The bolt *T* was taken out, the high-pressure piston put back on the rod, and the large plug *E* put into its place. The cylinder head *C* was put on, but piston *D* was left out, and by readjusting the spools at *K* the pump ran very satisfactorily until a new piston could be secured.

ALBERT CARPENTER.

Adams, Mass.

Lubrication

Your Mar. 23 editorial, subject "Lubrication," suggests a few comments. Modern equipment such as high-pressure compound condensing reciprocating engines, turbines, and Diesel, producer gas, locomobile and uniflow engines, air compressors of several stages, also eight- and twelve-cylinder automobile engines, require the best oil obtainable; any other kind retards smooth operation. Some engineers admit that their engines are better judges of good oil than they are.

The present standard of oil analysis needs revision. Oils varying in chemistry and physical properties materially render selection difficult. Few buyers are able to differentiate between the good and the bad. The Independent Petroleum Marketers' Association, recognizing this deficiency, selected a committee of experts about two years ago to investigate this situation, but so far no report has been made, nor has any new standard been adopted.

Most of the crude oil produced in this country, or about 76 per cent., is of asphaltic base and of low market price. The other 24 per cent. is of paraffin base, ranking very high; in some instances a premium is paid for it. It is the difference between the two that puzzles many engineers. To them the finished oils look alike, whether Eastern or Western products, but when the asphaltic-base oil is used under high-pressure modern conditions, the asphalt condenses at its critical temperature. This deposit may be found in cylinders, packing rings and piston rods, accumulating until sheared off. It causes engines to labor hard, calling for increased oil supply and also finds its way into condensers, reducing their efficiency. Asphalt has no lubricating value and should be abandoned when trouble presents itself.

The paraffin-base oil, mainly from Pennsylvania, has the reputation of being the most reliable oil found anywhere. It is becoming scarcer every year. During 1914 the production in Pennsylvania fell off 963,282 bbl. If the same ratio continues, in about eight years it will cease.

The widely used red engine oil, being of an asphalt base, wears rapidly. It disintegrates after being fed to the bearings a few times and causes abrasion. Next, an imperceptible wear of the metallic rubbing surfaces begins and the oil finally finds its way into the filters, dirty, with its lubricating value reduced until it is gradually worn out. In a short time another barrel must be ordered. Its ultimate cost is high. Buyers may recognize herein why they find it necessary to order oil so frequently. The remedy is to install an outfit which returns the used oil to a filter, and adopt a bright-yellow, good oil (not acid-treated) which may be fed by drops, or in a stream in hot weather. Such an oil wears longer and needs little replenishing and that at longer intervals. Its ultimate cost is low.

Under any given conditions the oil which results in the lowest cost, owing to consumption, cost of coal needed to overcome frictional resistance, and cost of repairs due to metallic wear on metallic journals and brasses, is the best.

A modern high-pressure compound condensing engine requires the best oil obtainable. Such oil cannot be bought at a low price. But it may be the cheapest in the long run. Dependability, long service and ultimate cost are the determining factors. When engines labor and groan and valve and eccentric rods vibrate, or traces of asphalt appear, an immediate change of oil is advisable. Soft spots may appear in cylinders, causing wear, or leaky throttle valves, causing corrosion when the engines are idle. Or the trouble may be due to stale, rancid animal oil used in animal-oil compounds, coming in contact with hot steam and decomposing, forming acids. This causes soft spots, and if not remedied will result seriously. No reputable oil company will use rancid animal oil, or rancid wool fat or De Gras, which may be detected by its odor. Animal oil for compounding should be sweet and fresh and preserved in refrigerators when the temperature is above 50 deg. F.

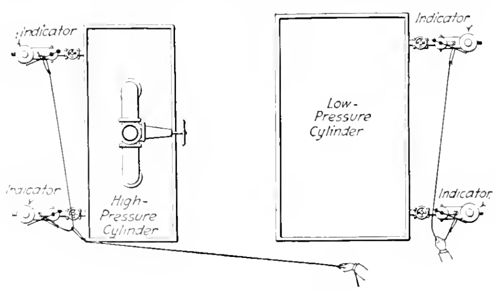
The writer's method of handling lubrication problems is to diagnose each case by itself. With practiced eye and well-trained ear the remedy is simple. In general, the modern uptodate little-drop method of cylinder lubrication supplied by a mechanical lubricator operated from the valve movement, when accompanied by a good oil, results in perfect lubrication, requiring the smallest consumption, at the lowest ultimate cost.

JOSEPH W. FROMEYER.

St. Louis, Mo.

Taking Two or More Diagrams Simultaneously

Taking diagrams simultaneously is essential for the purpose of accurately determining the horsepower developed, and also for valve setting. Sometimes it is neither convenient nor possible to make use of the magnet attach-



OPERATING FOUR INDICATORS

ments in handling two or more indicators. In using magnets dry batteries and wiring connections must be provided. The magnets must be delicately adjusted in order to make the proper pencil mark, and considerable time and trouble are entailed in making such adjustments. In lieu of magnets the following method may be adopted:

At each end of a cord about two feet longer than the distance between the indicator cocks make a loop about six inches in length so that there will be no knots to interfere, pass the loop over the pencil arm, which has been previously provided with an elastic band to hold the pencil off when not indicating. We now have a flexible connection to both indicators, and a pull on the cord will take as many diagrams as desired.

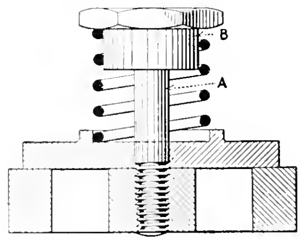
When indicating a cross-compound engine a third cord may be looped about the cord on one cylinder or the latter may be of sufficient length to reach the other cylinder where the operator can control all four indicators simultaneously. I have found this method simple and convenient.

L. L. LOOMER.

Waterbury, Conn.

Repairing Pump-Valve Studs

This will help out if your stock has run out and the pump valves have to be repaired before new studs can be obtained. Cut off the old valve stem and use the top part *B* as a nut after it has been drilled and tapped, then



HEAD USED AS A NUT

take a bolt or brass rod and make a stud *A*. This will answer the purpose as well as a new one. The nut may be pinned or riveted on if necessary.

JOHN M. RUPPERT.

Philadelphia, Penn.

Condensation from Waterwheel Casing

Waterwheels expose to the air a large surface which sweats under certain atmospheric conditions. Disposing of this water becomes a troublesome job to the operating engineer.

A channel or flange is usually cast around the periphery of the sub-base and drained to the tailrace. On the 20,000-hp. units in a certain plant several hundred square feet of surface are exposed to the heated air of the power house and the condensation is copious. During the first months much of the operator's time was taken up in disposing of the condensation collecting in the drainage channel, as the operating conditions made it inadvisable to utilize the customary drainage tubes.

The wheel, revolving rapidly in the closed casing, always produces a considerable vacuum at the shaft. This vacuum was utilized through a ⅜-in. pipe tapped into the casing, fitted with a valve, and extended to the drainage channel to remove the water.

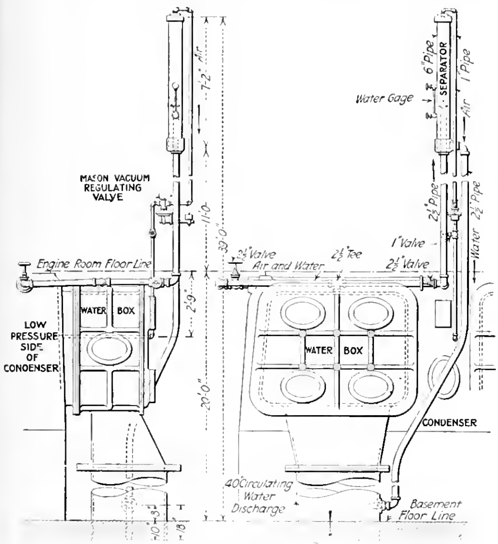
WALTER SWAREN.

Hayward, Cal.

Removing Air from Condensers

At the steam station serving the Twin City Lines we have five Curtis turbines of the vertical type, equipped with Worthington three-pass condensers. A great deal of trouble was caused by the accumulation of air, especially in the water box at the end of the last pass. The top of this box is about twenty-four feet above the level of the water in the river, both the intake and discharge pipes being submerged, making a sealed system.

Various devices were tried to remove the air, among them the plan of tapping the top of the box and connecting to the condenser, the pipe being fitted with a globe valve which was opened and closed by hand. The objection to this scheme was that, if the valve was opened too wide, too much water would be taken over into the



Air Receiver and Pipe Connections to Condenser

condenser. We tried to overcome this by extending the pipe in the form of a loop ∩, the upper part being about forty feet above the river level, but we found that the water would go over in "slugs". We then decided on placing a separator in the uptake side of the loop, and one was made up of 6-in. pipe and fittings approximately the same as shown in the accompanying illustration. Later, we applied the Mason vacuum regulator and have found the 1-in. regulator, with a pipe of the same size, large enough to handle all the air.

"Slugs" of air and water pass up the 2½-in. pipe into the separator through the short piece of pipe shown by dotted lines, the water separates from the air and flows out through the discharge pipe into the circulating discharge. By means of the weights on the lever of the regulator it is possible to obtain any desired vacuum in the separator.

We have found that this device gives excellent satisfaction, and when once adjusted, it needs no further attention on the part of the engineer.

Geo. W. Caywood.

Minneapolis, Minn.

Engineers' Salesmanship

Some time ago there was an editorial in Power on this subject, and it may not be too soon to bring it up again. At that time it was stated that the engineer applying for a position as salesman is handicapped through lack of actual selling experience and because he has no past record of sales ability. The questions now arise: What is sales ability? What qualities must the successful salesman possess?

In order to approach a business man at all it is necessary that one be neat in personal appearance; then, when one gets to his man, one must have a fair command of English and a pleasant disposition to start a conversation and, once the conversation is started, self-confidence in the line and oneself, together with a thorough knowledge of the specialty offered for sale, to maintain the conversation until the goods offered have been shown up at their best. There is such a thing as saying too much in some cases; therefore, tact and a knowledge of human nature are also required.

The qualities mentioned are the principal ones that go into the makeup of a successful salesman. What has the practical engineer to offer his prospective employer in the sales game? The engineer, to be successful in even a fair-sized plant, must have all the qualities mentioned above, with a few more thrown in. He must be tactful, to keep his crew working smoothly; he must be neat about himself and the plant; he must have an agreeable nature, to keep peace with his employer and the tenants in the building; he must have a thorough knowledge, not of one, but of a dozen and one different appliances to keep his plant going; and he must possess facts and figures and know how to present them when he and the central-station man meet on the mat in the manager's office.

The engineer, therefore, can offer the manufacturer of steam specialties the same qualities that the salesman can, plus practical experience, which more than offsets the lack of actual selling experience in the beginning.

The manufacturer should bear in mind a few proved facts. Many a perfectly dependable piece of apparatus has been returned to the makers and condemned because it failed to do what it was sold to do. Why? Because it was installed under conditions where it could not operate efficiently, or otherwise. It was sold by a man who was only a salesman and did not know whether it would operate. A practical engineer would have made no such mistake; he would know from experience that only failure could result.

It is to the interest of the manufacturer, not only that an appliance should operate, but that it should operate at maximum efficiency. Repeat orders are the life of a concern, and a good piece of apparatus will fail unless properly installed.

Last, but not least, while the engineer is not always the buyer he can always be the knocker. An engineer salesman can walk into a plant, and being an ex-engineer, he usually has no trouble making a friend of the average engineer. He sees things about the plant an ordinary salesman would not notice and can probably make suggestions which will lead to a sale. He asks questions the average man would not think of and gets information which the ordinary salesman could not obtain. If there is a complaint about anything he usually gets it first, and thus has the opportunity of correcting the fault before it goes further and causes unpleasant business relations. While going about he can collect trade data at little or no cost; data which usually cost the manufacturer quite a little to secure through other sources.

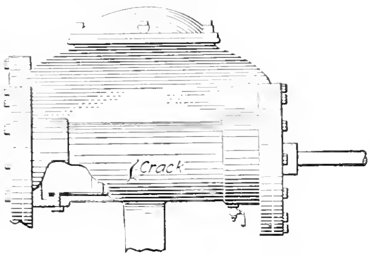
The average buyer of today appears to hail from the corn-cob state; he must be shown, and who is better qualified to show him than the man who can get into a pair of overalls and install and operate his plant? All engineers will not make good salesmen, but in view of what is required of the modern engineer one can safely say that a larger percentage of men who can qualify for salesmanship in the engineering field can be taken from the ranks of the operating man than from any other body of men.

A. H. Pohlman.

Brooklyn, N. Y.

Emergency Pump Repair

In the plant where I am employed a small vacuum pump on the returns from the heating system developed a crack about three inches long in the cast-iron cylinder of the water end. When we overhauled it we found that the crack did not extend through the brass lining and that



Plug Extended into Lining

the water got in between the iron and brass at the drip opening. We screwed a brass plug into the drip opening flush with the bore and smoothed it up nicely. On starting the pump the crack did not leak a bit and had closed up somewhat.

I think the pressure between the lining and the cylinder forced the crack open, as at times it has to work very hard.

Howard H. Whitaker.

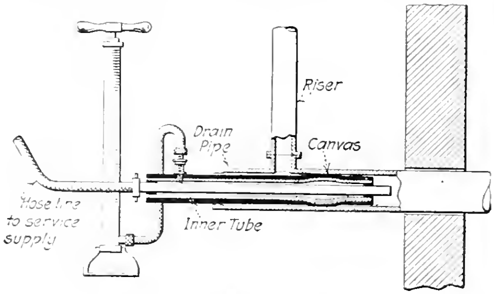
West Somerville, Mass.

A Pneumatic Pipe Stopper

Difficulties are encountered at times in clearing out obstructed drain pipes on account of abrupt turns in the piping, which a steel "snake" or its equivalent is unable to pass around, and it is necessary to use a hose connected to the hydrant pressure to clear the obstruction.

If, however, a plug is removed and a hose connection made, the water, instead of passing through the obstructed piping, will ascend in risers and overflow from the sinks or washbowls above. A case of this kind recently came within the writer's personal experience. The 3-in. drain pipe, with a 2-in. screw plug in the end, passed through a basement wall. About 12 in. from the end of the pipe a 2-in. riser extended to the floor above.

To make a water-tight connection with the drain pipe and prevent backflow in the riser, the device shown was made up in a few minutes from material that happened to be at hand. A 2-ft. piece of a bicycle inner tube, having the valve attached, was cut off and slipped over a $\frac{3}{4}$-in. iron pipe and bound tightly at each end by winding stout cord about it and the pipe. Over this a piece of



Pneumatic Stopper in Use

3-in. cotton hose was placed and bound in like manner. A line of hose was attached to the service supply and connected to the $\frac{3}{4}$-in. pipe, and the end was inserted in the drain pipe as shown and the tube inflated with a foot pump, which produced a water-tight coupling.

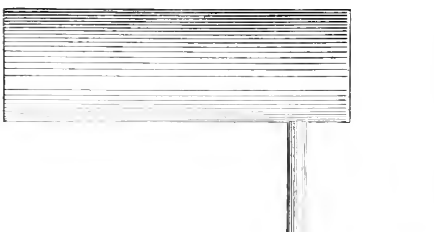
T. H. Reardon.

Pittsfield, Mass.

Blowoff Piping

The company for which I am working built a new plant a year ago, and the blowoff piping was something novel to me, although it may not be to all readers of Power.

The engineer who has had to go into a hot combustion chamber and install a new blowoff pipe after an elbow has failed will appreciate this arrangement, as it does away with a threaded elbow. The pipe should be extra heavy



Bent Pipe for Blowoff

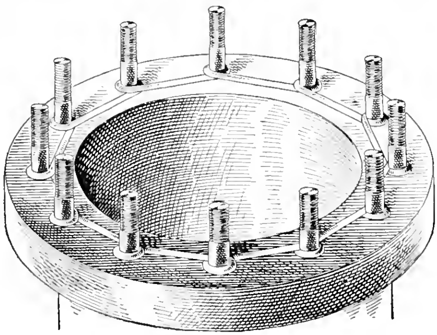
and will be better if made of wrought iron, which is easily bent. This leaves a clear passage for scale and sediment in blowing off the boilers, and if properly protected, I see no reason why it should not last for years; it will certainly reduce the danger from water-hammer and elbow failure. The company furnishing this equipment always uses a bend instead of an elbow, wherever possible.

J. A. Epply.

Thomasville, Ga.

An Emergency Gasket

The writer has used a gasket for a steam main, made as shown in the illustration. Long pieces of lead rope were inserted between the pipe flanges and wound around the bolts. A mixture of red lead and linseed oil was then added, the whole being flattened and spread out by



Lead Rope as a Gasket

the strain on the bolts. This form of gasket may be tightened as required from time to time, taking care that the lead does not spread too much and project into the bore of the pipe.

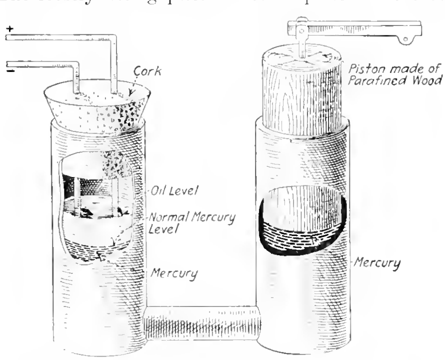
T. W. Reynolds.

New York City.

Signal-Circuit Make-and-Break

Use a U-tube of glass or iron pipe, into which the wires should be fastened by pushing through a cork and varnishing, or, if the tube be of glass, they may be fused in place. The tube should then be filled with mercury to a point slightly below the ends of the wires and enough oil put on it to cover the tips of the wires.

The loosely fitting piston is to be placed in the other



Electric Circuit Completed by Rise of Mercury

side of the tube and so connected to the float or mechanism that is to operate it, that it will be depressed and displace enough mercury to cause the column to rise in the opposite side and close the circuit by submerging the points of the wires. This will be accomplished away from the air and under oil, and may be used with safety around gas or other explosives.

This device does not require attention, as the oil cannot "creep out." It can be made as acid- and fumeproof as the electric conductors themselves, and also "foolproof."

H. King.

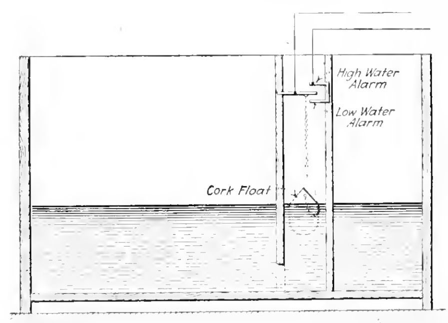
Wilkinsburg, Penn.

Tank Float and Alarm

The illustration shows a high- and low-water alarm for a tank, which we developed after considerable experimenting.

The situation was more difficult than usually met with, on account of the water being supplied to the tank by two pumps discharging at opposite ends of the tank, the agitation causing waves which kept the float and switch in almost constant motion.

A casing open at the bottom was fastened inside of the tank in which the float was placed, and after this the



Float Inside of Casing

surface agitation had little effect. The rising and lowering of this cork float opens and closes the electric circuit which rings the alarm bell in the engine room. The float fits in the casing so as not to turn over, and the light chain allows considerable variation in the water level before the alarm sounds.

Irving Cobb.

Atlantic City, N. J.

A Broom Handle in the Cold-Water Pipe

A water-heating plant gave off various noises and our steam fitter was called to remedy it, and I was invited to go along. The heater was in the basement, and as we entered, the pipes gave off a continual chatter, then got quiet for a time, and then jerked in a way likely to tear the piping out.

At first we thought the steam fitter had got confused in his connections at the top of the tank, but the system had been in successful operation one winter. After finding this connection right we took down the cold-water pipe and found a piece of broom handle inside, which at first was a loose fit in the pipe, and it let the water past for a time, but had filled with sediment, with the results mentioned.

J. N. Woodruff.

W. Liberty, Ohio.

Stand-by Plant Supplying Steam to Central Heating System

The Northwestern Electric Co operates an 18,000 horsepower hydro-electric plant on the White Salmon River. The plant supplies energy to the City of Portland, Ore. A reserve was needed in order to back up the water-power station. The plant installed is described by G. Broili, in the "Journal of Electricity, Power and Gas." It was found that in order to serve the public properly, either a storage battery or a steam plant would have to be installed. The steam plant was finally chosen because of the possibility of installing a central heating system.

Two 3500-kw. turbines were placed in the basement of a large Portland office building. These turbines operate noncondensing and act as voltage regulators on the electric end by varying the field excitation. The turbines can be made to carry enough load to furnish the steam required for the heating system, or the steam can be bypassed through reducing valves, or a combination of both can be used. As the turbines are always connected to the electrical system, they will quickly take up the load should there be any interruption of the service from the water-power plant. No delay can take place, such as often happens on many hydro-electric systems where the steam plant must be brought quickly into operation in emergencies. These turbines are ready to put out their full capacity at all times for an indefinite period, which is not the case with a storage battery.

In ordinary operation one or two turbines are run and all the steam required for the heating system goes through the turbines, carrying a part of the load. An automatic governor developed at the plant keeps the low pressure to within one-half pound of whatever is required. The plant has been operating successfully since starting. The boiler pressure is 185 lb. with 125 deg. superheat. The amount of superheat is greatly reduced in the turbines, but when any steam goes through the reducing valves, there is trouble in the heating main due to the excessive superheat. While a cold spray of water in the heating main beyond the reducing valve will absorb the superheat, experiments are in progress to perfect a system that will be more desirable.

The results obtained show that the central-station service is financially satisfactory, not to mention the item of service which is hard to estimate in money. Steam heat has been furnished for one year to an office building with 152,000 cu.ft. of space, and 1321 sq.ft. of radiation. In a previous year, the fuel cost was $438.40 and the labor cost $520, making a total of $958.40. The steam heat from the central station costs $520 for the year, thus making a saving of $438.40 over the fuel costs in the private plant. Another case is given of a well-built hotel, three years old, with 640,000 cu.ft. of space and 3650 sq.ft. of radiation. The fuel cost during 1913 in the private plant is compared with the net central-station steam cost for 1914 in the following table:

Month	Private Plant (Fuel only)	Cent. Heat. Total
January	$194.60	$145.58
February	174.65	118.58
March	124.75	80.00
April	99.80	67.86
May	99.80	55.10
June	24.95	31.50
July	24.90	40.50
August	49.90	44.01
September	49.90	71.28
October	99.80	99.50
November	123.75	123.53
December	212.54	132.43
	$1179.34	$1009.87

These figures show a fuel saving of $169.47, but in addition to this there was a saving made in labor amounting to about $1200 per year, making a total of about $1370. It will be noted that in the milder months of winter and in summer, central-station service exceeded in cost the amount paid for oil fuel for the private plant. This is explained by the fact that with central-station service better heating is enjoyed at all times and more hot water is used because of its being available, thus giving the hotel tenants a much more satisfactory service in every way.

The pressure in the heating mains is about 5 lb. Two 20-inch lines leave the station, and the sizes are gradually reduced. The lines are tied in with cross-lines wherever possible. Condensation in the mains averages about 0.025 lb. per hr. per sq.ft. of pipe surface and is practically constant regardless of the load or time of the year. Radiation of heat from the underground pipes is reduced to the lowest possible amount by the use of a very efficient insulation made to surround the iron steam pipe. First a layer of asbestos paper is carefully wrapped around the pipe, then an air space of about one inch is provided by centering the pipe within a heavy wooden-stave pipe casing. This casing is lightly banded with steel wire and painted with heavy tar paint. The interior is lined with bright tin to reflect radiated heat from the iron pipe, and between the tin and the wood is a sheet of asbestos to prevent charring of the casing. Expansion and contraction are taken care of by special joints known as variators, placed about every 50 ft. along the street trenches. The right-angled house service connections are taken off at the anchored point where needed.

To Calculate the Horsepower of a Stream of Water

The table gives the horsepower generated by one cubic foot of water per second (7.48 gallons) falling a distance of one foot, which is 0.0965 horsepower, or 72 watts, and is the basis upon which the following table was calculated.

HORSEPOWER GENERATED BY ONE CUBIC FOOT PER SECOND, FALLING DISTANCE 5 TO 200 FT.

Fall or Head in Ft	Hp. of 1 Cu Ft. or 40 In Water	Kilowatts	Fall or Head in Ft.	Hp. of 1 Cu.Ft. or 40 In. Water	Kilowatts
5	0 483	0 360	35	3 380	2 521
6	0 579	0 431	40	3.860	2 876
7	0 676	0 504	45	4 340	3.237
8	0 772	0 575	50	4 820	3 595
9	0 869	0 648	55	5.310	3 961
10	0 965	0 718	60	5.790	4 319
11	1 062	0 792	65	6 270	4 677
12	1 159	0 865	70	6.760	5 042—5 kw.
13	1 255	0 936	75	7 240	5.401
14	1 352	1 008—1 kw.	80	7.720	5 759
15	1 448	1 080	85	8.210	6.124
16	1 545	1 152	90	8.690	6.482
17	1 642	1 225	95	9.170	6 840
18	1 738	1 296	100	9.650	7 198
19	1 835	1 368	125	12 070	9.604—9 kw.
20	1 932	1 441	150	14.48	10.802
25	2 410	1 797	175	16.90	12 607
30	2 890	2 890	200	19 31	14 405

Equivalents from this table may be converted to suit any case by multiplying the horsepower of 1 cu.ft. of water under any head by the head in feet times the number of cubic feet per second of water available.

For determining the flow of a stream, or the amount of water available for power purposes, the water is measured by means of a weir—an instrument quite well-known in all of the irrigating districts. A small weir table is appended.

TABLE FOR WEIR ONE FOOT IN LENGTH

Depth in In. on Crest	Quantity in Cu.Ft per Sec. for Each Ft. in Length	In Miners In.	Depth in In. on Crest	Quantity in Cu.Ft. per Sec. for Each Ft. in Length	In Miners In.
1	0 08	3 2	7	1.50	60
1½	0 15	6	7½	1 66	66
2	0 23	9	8	1.81	72
2½	0 30	12	8½	2.00	80
3	0 40	16	9	2 18	87
3½	0 50	20	9½	2 35	94
4	0 65	26	10	2 55	102
4½	0 77	31	10½	2 75	110
5	0 90	36	11	2 93	117
5½	1 04	42	11½	3 15	126
6	1 18	47	12	3 35	134
6½	1 34	54			

This table was calculated for depths of water from one to twelve inches by one-half inch increments and for a weir width of one foot.

The Cost of Employing Incompetents

At a recent gathering of machine tool builders it was stated that it costs $30 to $35 to engage a workman, test him and discharge him if inefficient. This figure is based on the records of a large manufacturing plant, and it is easy to see how much can be lost per annum if great care is not exercised in selecting the new hands. It is even more necessary to be careful in putting new men on a power-plant staff, since an incompetent man may cause damage running into thousands of dollars in a very short time. The quality of the work done by a mechanic or machine operative can be very quickly gaged, but it is not so easy to estimate the abilities of a shift engineer unless he blunders right at the start. A keen chief will, of course, get to know the caliber of his man before very long, but an emergency may occur, and the mischief may be done before the discovery of incompetence has been made.

Heat Generated in a Circuit represents work done in overcoming the resistance of the circuit.

Ammonia a Heat Vehicle

By Albert Johnson

[The following paper by Albert Johnson, of the Herf & Frerichs Chemical Co., was first read before the American Meat Packers' Association, Chicago, and since then has been read before other like organizations. The explanations and presentation will commend it to those new at operating refrigerating equipment.—Editor.]

HOW AMMONIA CONVEYS HEAT

Let us see how anhydrous ammonia becomes a conveyor of heat. When one pound of anhydrous ammonia has passed through the regulating valve into the low-pressure pipes it remains a liquid until it can grab hold of from 500 to 600 B.t.u. of heat. Then the pound of liquid changes into a pound of gas. But it refuses to change from liquid to gas until that much heat leaves the room and enters the liquid ammonia on the inside of the coils, thereby turning it into gas.

The changing of the liquid into gas is what absorbs the heat. Therefore, it is always necessary to have plenty of liquid ammonia within the low-pressure pipes.

Do not, under any circumstances, allow gas to pass through the regulating valve, for then you only add heat to your rooms instead of subtracting it. Remember, the gas is the loaded vehicle, while the liquid is the unloaded vehicle, being empty. The liquid has plenty of room for heat units, but the gas has little room for heat units, since it is already loaded with them. It cannot carry any more. So it is well to watch and see that only liquid passes the regulating valve into the low-pressure pipes.

This is a more serious question in operation than you may think possible, and the subject is more fully covered in my former paper read before the International Congress of Refrigeration, and entitled "The Value of a Liquid Seal," which can be had upon application, free of charge.

Bear in mind that it requires heat to vaporize ammonia—the more heat, the quicker the evaporation; whereas, the less the heat, the slower the evaporation, which explains why "sharp freezers" are so apt to fill up with liquid in abundance, while the rest of the system may be suffering from the lack of liquid.

After the liquid has been changed into vapor by the heat, it has practically spent its energy as a refrigerant, for the gas has obtained its full load of heat and is ready to carry it away.

USE OF THE REFRIGERATING MACHINE

So far the ammonia, or vehicle, has been "running down hill," requiring no power. At the bottom of the hill is the loading platform where the heat is taken aboard. After this it's an uphill pull, and a good strong horse is required to pull it up to the unloading platform. The horse may be called a "refrigerating machine."

The machine gets behind the heat-laden gases in the frosted low-pressure pipes and pushes them up to the top of the hill to the unloading platform, or ammonia condenser, where the loaded gas is changed back into a liquid. Just at the moment when the gas becomes a liquid it releases or dumps out the heat that it formerly picked up in the rooms, and the water in the condenser then absorbs the released heat units and carries them away.

Thus we see how necessary is the refrigerating machine to push the loaded vehicle, ammonia, along the uphill grade of high pressures direct to the top, or unloading place, at the condenser. But that is all it has to do, for the real work of freezing is performed by the ammonia, not by the machine. The initial as well as the final operation is done by the vehicle called ammonia, which must not be forgotten.

Thus you can readily see how anhydrous ammonia actually becomes a so-called vehicle for removing heat units from insulated rooms and carrying them, with the aid of the refrigerating machine, upstairs or downstairs, around corners and angles to condensers, there to unload its heat. Then it goes back to repeat the operation.

WRONG NAME FOR A VALVE CAUSED TROUBLE

A regulating valve controls the flow of liquid ammonia into the low-pressure pipes. That is all it is there to do. It cannot do any freezing, since only the ammonia does that. I mention this because, way back in the early days of this industry, somebody misnamed that valve—the expansion valve—without thinking of the consequences.

Ever since then many operators got the erroneous idea that this valve actually did the heavy work of freezing, and they would fondle it and handle it, fuss over it and play with it, sometimes resetting it twenty times a day, then listening to hear the gas gurgle or spit through it. The misnaming of this valve has cost the owners of plants hundreds of thousands of dollars in time lost fooling with it and in lack of efficiency caused by relying on this valve during critical moments of climbing temperatures, when the receiver should be watched instead. It is best to call it a regulating valve, to save confusion of ideas, much money and false impressions.

When I speak of heat-laden gases in suction pipes it may surprise you. Try to put your hand on a frost-covered suction line and imagine it contains real heat. It actually does, and lots of it, only it is called latent heat, or insensible heat. A thermometer cannot register it, nor can you feel it by touch. But it is there just the same. Apparently, the pipe is very cold, for it is usually covered with frost, yet the cold gas inside of that pipe will deliver heat enough to warm up enormous quantities of condensing water from 10 deg. to 30 deg. F. per pound.

We learn how the vehicle ammonia is relied upon to take the initiative in the work of removing heat. It is essential to work with not only dry, but pure ammonia. Note the difference between dryness and purity, for volatile hydrocarbons may exist in the liquid itself, which cause abnormally high pressures. Such foul gases refuse to liquefy and they fill up the condensers.

These bad gases must be blown away. Hydro-carbon gases are both colorless and odorless, which makes them hard to find. They are hidden, and like latent heat we know them by the effect they produce when they refuse to liquefy, causing excessive fuel bills or power bills and great ammonia consumption.

It has been estimated that in order to purge 15 lb. of uncondensable or hydrocarbon gas from the system you lose 85 lb. of pure gas, because the two are closely associated or intermingled, so that when the purge valve is opened the good as well as the bad gases are liberated unavoidably together.

GOOD AMMONIA REQUIRES NO PURGING

Good ammonia requires no purging, for good ammonia is free from volatile hydro-carbons. The evaporation test does not disclose the presence of volatile carbon compounds, for they evaporate together with the ammonia. The working test seems to be the most reliable. The test for air in shipping cylinders means little as to quality and has the disadvantage of being deceptive.

Ammonia is like fullers' earth, because both require a working test to prove their effectiveness. In both cases results count more than analysis. A chemical report on fullers' earth is about as valuable as a chemical report on anhydrous ammonia. However, in making an exhaustive examination of ammonia a thorough chemist will demand to see the raw material as well as the finished product. In testing cement, for instance, a thorough chemist will also examine the clinker or raw material as well, in order to obtain data for proper valuation. The clinker may be overburnt or underburnt, and the chemist is right in demanding a sample of the raw material.

The purchase of anhydrous ammonia should be like the hiring of a man. You expect a man to perform some service and keep on doing so. In purchasing ammonia you must expect it to serve you by picking up or absorbing all the heat units possible and unloading them in large quantities day by day, without getting tired or worn out on the slightest occasion. Remember, you do not buy ammonia like other merchandise, to be sold to others from the shelf. Instead of that, you invest your money in an article that must work for you day and night, and produce results in heat-carrying capacity. For, to produce one ton of refrigerating duty the vehicle, ammonia, must fetch and carry away 288,000 B.t.u. of heat from insulated rooms in the shortest time possible, and that is why the question of ammonia as a heat vehicle is so serious as to affect the profits in a refrigerating plant.

New Electric Rate at Ottawa

Electricity for cooking at a price equal to 50c. gas is what Controller Ellis, of the Ottawa Municipal Electric Department, has attained for the city. The present price of gas is $1.25 per thousand cubic feet, less 12 per cent. discount, plus a $2 a year meter rental, or about a net rate of $1.20 per thousand cubic feet.

The annual report of the municipal electric department for 1914 pointed out the reduction in rates since the hydro-electric installation was first made. At that time the rate was 8c. per kw.-hr., less 10 per cent. discount, with no floor-area charge; whereas now the rate is 2c. net per kw.-hr., and 3½c. per 100 sq.ft., less 20 per cent. discount, for floor space, and 1c. net for excess current used other than for lighting.

American Association of Refrigeration

The annual meeting of the American Association of Refrigeration was held in the Hotel Astor, New York City, May 11 and 12. Inasmuch as the association interests itself more in the commercial application of refrigeration than in its technical and engineering side, operating engineers have little to gain from a knowledge of its activities other than to get a broad perspective of the state and advance of the application of refrigeration. To be sure, this is important and it is from this angle that the operating engineer should watch what the association is doing.

The meeting consisted chiefly of three business sessions and a banquet. As President Frank A. Horne, of New York City, was not present at the first session, Past-President Homer McDaniel, of Cleveland, opened the meeting.

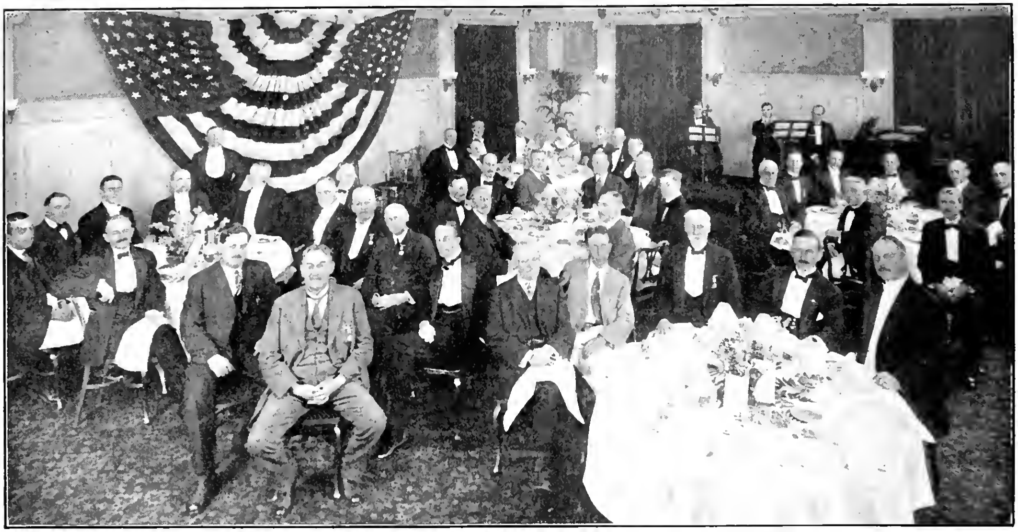
In his address Mr. Horne approved the recommendation of the commission on legislation and administration that the association authorize the engagement of a reporting agency to keep the association in the closest possible touch with proposed legislation—local, state and national—affecting the refrigerating industry. Mr. Horne also recommended the engagement of a paid manager, who, working under the secretary, would devote his whole time to the affairs of the organization. That the president feels the need of more vigorous, extensive and complete committee work was evident from the manner in which he explained the need and value of committee reports.

Dr. H. Dannenbaum, chairman of the committee on trade extensions, in his report stated that the reports of the Department of Commerce show that the value of ice and refrigerating machinery exported from the United States in the fiscal year ending June 30, 1914, was $978,457. Of this, Europe's purchases amounted to $34,883; North America's $271,843; Asia's, $100,010; South America's, $428,266; Oceania's, $138,091; and Africa's, $5364.

The Commission on Legislation and Administration requested Dr. Pennington and Dr. Barnard and Mr. Coe to draft a Federal storage law to be similar to the uniform cold-storage law already drafted.

The banquet, held in the College Room of the Hotel Astor, was enjoyable, and among the speakers were Borough-President Marcus M. Marks; Dr. Mary Pennington, chief of the food research laboratory of the Bureau of Chemistry and chairman of the association's committee on state and national investigations; G. Harold Powell, general manager of the California Fruit Growers' Exchange; and Homer McDaniel, a past-president of the American Warehouseman's Association.

All the officers, with the exception of J. H. Bracken, chairman of the testing committee, were last year's officers reelected: President, Frank A. Horne; vice-president, E. O. McCormick, Thomas Shipley, Homer McDaniel, Col. Jacob Ruppert, Jr., James Craig, Jr., Roderick H. Tait, R. H. Switzler; secretary, J. F. Nickerson; treasurer, John S. Field; chairman of Executive Committee, William J. Rushton; chairman of Advisory Committee, H. W. Bahrenburg; chairman of Committee on Papers and Lectures, Dr. F. W. Frerichs; chairman of Finance Committee, Theo. O. Vilter; chairman of Committee on Trade Extensions, Dr. H. Dannenbaum; chairman of Committee on State and National Investigations, Dr. Mary E. Pennington; chairman of Board of Engineers on Educational Work, Gardner T. Voorhees; chairman of Commission on Gases and Units, Prof. Edward T. Miller; chairman of Commission on Testing Refrigerating Machinery and Insulating Materials, J. H. Bracken; chairman of Commission on Application of Refrigeration to Foods, G. Harold Powell; chairman of Commission on Industrial Refrigeration, Peter Neff; chairman of Commission on Railway and Steamship Refrigeration, Carl Howe; chairman of Commission on Legislation and Administration, E. O. Whitford; chairman of Publication Committee, N. H. Hiller; chairman of Committee on Membership, Bruce Dodson; chairman of Press Committee, E. D. Ansley.



BANQUET OF THE AMERICAN ASSOCIATION OF REFRIGERATION, HOTEL ASTOR

To Calculate Steam Required to Operate Pump

For a direct-acting pump in fair condition, operated at a piston speed of 100 ft. per min., assume an average steam consumption per indicated horsepower-hour of, say 150 lb. dry saturated steam, which is a so-called "water-rate" of 150 ÷ 60 = 2.5 lb. i.hp.-min.; and multiply this water rate by the indicated horsepower of the pump, as shown by the following:

Find the steam required to pump 9000 gal. of water per hour, from a shaft 450 ft. deep, using a simple direct, double-acting pump running at a speed of 100 ft. per min. and discharging through a 3-in. column pipe.

The effective head, in this case, is

$$h_1 = 450 + \left(\frac{9000}{60}\right)^2 \frac{450}{800 \times 3^5} = \text{say } 502 \text{ ft.}$$

The indicated horsepower of this pump will then be

$$H = 0.00034 \times 150 \times 502 = 25.6 \text{ hp.}$$

The weight of steam required to operate this pump, under the assumed conditions, will be

Steam consumption,

$$2.5 \times 25.6 = 64 \text{ lb. per min.}$$

—"Coal Age"

Recent Court Decisions

Digested by A. L. H. STREET

Rights of Water Consumers—A water company which shut off water from a customer's hydraulic elevator on the latter's refusal to pay an excessive bill, is liable for resulting damages sustained by the customer, regardless of whether the error in the bill was innocent or deliberate, according to the decision reached by the Court of Appeals of Kentucky in the late case of Louisville Tobacco Warehouse Co. vs. Louisville Water Co., 172 "Southwestern Reporter," 928. The court, however, upholds the right of a water company to make any reasonable regulations for the conduct of the company's business, including the cutting off of service for nonpayment of just charges which have accrued. But all regulations must apply to all persons similarly situated.

Duty to Install Lightning Arresters—An owner of an electrically propelled passenger elevator is liable for injury resulting to the operator from shock caused by lightning, if the accident be attributable to the owner's failure to install lightning arresters, according to the holding of the Springfield, Mo., Court of Appeals, in the case of Melcher vs. Freehold Investment Co., 174 "Southwestern Reporter," 455. Speaking of the measure of care to avoid injury resulting from use of electricity as power, the court declares that ordinary care requires the exercise of the highest diligence to take precautions against accidents, by installing such safety appliances as are reasonably available. And the decision adds that, since lightning arresters are well-known devices, an owner of an elevator who fails to install one cannot avoid liability for accidents of the kind mentioned by showing that other persons owning similar buildings have not installed them.

Suit for Flowage of State Lands—Suit was brought by the State of Minnesota against the Minnesota & Ontario Power Co., for $200,000 damages claimed to have resulted from flowage of 30,000 acres of state lands along the international border in the maintenance of the company's power dam across the Rainy River. The company, in addition to operating large pulp and paper mills in northern Minnesota, supplies electric light and power to various industries and municipalities. The state threatened another similar suit against the same company on account of prospective flooding of 50,000 more acres of public land near Kettle Falls on the same river, where the company is constructing another power dam. The suit brought, by omitting to claim any right to enjoin operation of the dam, recognizes the validity of the right granted to the company by the United States and Canada to maintain the dam.

Liability for Explosion of Boiler—An employer may be held responsible for injury to an employee, caused by explosion of a defective boiler after the making of repairs thereon, on the theory of negligence in failing to apply the hydrostatic test to the boiler, if that would have disclosed the defect. This is the holding of the Court of Civil Appeals of Texas, lately announced in the case of Ligarde vs. National Railway of Mexico, 172 "Southwestern Reporter" 1140, in which the plaintiff was awarded a verdict for $20,000, which the Court of Civil Appeals declares was not excessive, for injuries sustained by plaintiff in an explosion of a locomotive boiler in repair shops. The following statement of the court, bearing on the duty of inspection, would seem to apply to all classes of steam boilers:

> The engine was old, was in the shop for repairs, and it was the duty of appellant to apply all tests necessary to ascertain how much steam the boiler would sustain. The only perfect test was the hydrostatic, and the jury was warranted in finding that the railroad company was negligent in not applying that test.

Contributory Negligence of Engineer—A stationary engineer, who, being thoroughly familiar with the working conditions of machinery, fails to take proper steps to stop the machinery before placing his hands in a dangerous position, in making repairs, cannot recover against his employer for consequent injury, even though there may have been insufficient light in his place of work. This is the gist of the decision of the Supreme Court of Wisconsin, announced in the case of Hansen vs. Campbell Laundry Co., 151 "Northwestern Reporter," 262. The plaintiff was the engineer in the defendant's plant and found it necessary to tighten some nuts in the mechanism of a pair of automatic underfeed stokers. Instead of shutting off the steam by using one of the three valves, which he knew would absolutely close off the steam, he turned a dial point to zero, and supposing that would stop the machinery, reached his hand into a steel case containing movable mechanism. There was sufficient escape of steam past a regulating valve to cause the machinery to move, and his hand was injured in consequence. He brought suit to recover for his injuries, but the Supreme Court holds that the trial judge properly denied recovery on the ground of contributory negligence. The Supreme Court attributes carelessness to the plaintiff in failing to use the valves, as affording the only safe means of stopping the machinery, and finds that any insufficiency in lighting of the premises did not contribute to the accident by preventing the plaintiff from using the valves, or by ascertaining whether the dial point was at zero.

PERSONALS

C. E. Lesher, associate geologist of the land-classification board of the United States Geological Survey, has taken charge of the work of compiling the statistics of coal production published in the annual volume "Mineral Resources." This work has heretofore been directly under Edward W. Parker, whose resignation from the Geological Survey is effective July 1.

ENGINEERING AFFAIRS

A. O. S. E. Convention—The American Order of Steam Engineers will hold its twenty-ninth annual convention at Atlantic City, N. J., during the week commencing June 21. The local convention committee, assisted by the officers of the American Supplymen's Association, are hard at work completing the final arrangements. The Continental Hotel on Tennessee Avenue has been selected as the headquarters, and the elaborate mechanical exhibit will be located at the Morris Guards Hall, on New York Avenue.

A. S. M. E. Spring Meeting—The spring meeting of the American Society of Mechanical Engineers is to be held at Buffalo, N. Y., June 22 to 25. The society has met at Niagara Falls before, but this will be the first time at Buffalo. David Bell is chairman of the local committee of arrangements; James W. Gibney, vice-chairman; C. A. Booth, secretary, and C. H. Bierbaum, treasurer. The Engineering Society of Buffalo is to join with the local A. S. M. E. members and engineers generally in acting as hosts. The headquarters will be at the Hotel Statler, where all sessions will be held except the first one, which will be at Niagara Falls in the large auditorium of the Shredded Wheat Biscuit Co. The papers to be presented include "Laps and Lapping," by W. A. Knight and A. A. Case; "Model Experiments and the Forms of Empirical Equations," by E. Buckingham; "Rational Design and Analysis of Heat Transfer Apparatus," by E. E. Wilson; "Influence of Disk Friction on Turbine-Pump Design," by F. zur Nedden; "A Study of an Axle Shaft for a Motor Truck," by John Younger; "Corrugated Furnaces for Vertical Fire-Tube Boilers," by F. W. Dean; "The Effect of Relative Humidity on an Oak-Tanned Leather Belt," by William W. Bird and Francis W. Roys; "The Relation between Production and Costs," by H. L. Gantt; "Design of Rectangular Concrete Beams," by Howard Harding; "Some Mechanical Features of the Hydration of Portland Cement and the Making of Concrete as Revealed by Microscopic Study," by Nathan C. Johnson; and "Surface Condensers," by Carl F. Braun.

Chicago A. S. M. E. Discusses the Electric Locomotive—Friday evening, May 14, was the last meeting of the season for the Chicago Section of the American Society of Mechanical Engineers. As usual, the meeting was an informal dinner session in the Red Room of the Hotel La Salle. At a preliminary business meeting the following officers were selected for the following year: H. M. Montgomery, chairman; Joseph Harrington, vice-chairman; Robert E. Thayer, secretary; other members of the committee, Charles E. Wilson and H. T. Bentley. The subject for the evening was the "Electric Locomotive." It was a timely topic for Chicago and a goodly number of the engineers took advantage of the opportunity to learn what has been done and what is being done in this field. A. F. Batchelder, chief engineer of the locomotive department, and A. H. Armstrong, assistant engineer of the railway and traction department, both of the General Electric Co., gave talks of exceptional interest on the subject. The former confined himself to the design and by means of numerous lantern slides traced the development from the first locomotive installed by the Baltimore & Ohio R.R. Co. in 1895 to the recent combination passenger and freight locomotives for the mountain divisions of the Chicago, Milwaukee & St. Paul Ry. The designs of truck, control arrangement, type of motor and other interesting features were illustrated in the numerous slides presented. Mr. Armstrong centered his talk on where the locomotive is used, the excuse for its existence and a comparison with the steam locomotive. He dwelt particularly on the Butte, Anaconda & Pacific 2400-volt direct-current locomotives, those of the New York Central and the immense machines recently built for the Chicago, Milwaukee & St. Paul Ry. Data on tractive effort, weight on drivers, efficiencies and limitations were given, and upon request were followed by an interesting summary on the development of current collectors. Both talks were highly appreciated by the audience, and no doubt valuable information was absorbed, which may help in the solution of one of Chicago's knotty problems—the electrification of its steam railways.

The National Association of Manufacturers will hold its 20th annual convention at the Waldorf-Astoria Hotel, New York City, May 25 and 26. Among those scheduled to address the convention are ex-President Taft, whose subject will be the "Clayton Act and Other Things;" Senator Warren G. Harding, of Ohio; Dr. Eugene L. Fisk, M. W. Alexander and Arthur D. Little. James A. Emery will outline the work of the newly created Federal Trade Commission. Walter Drew, of the National Erectors' Association, will discuss the work of the Federal Commission on Industrial Relations. Committees will report on fire and accident prevention, union label, immigration, uniform state laws, trademarks and copyrights, and industrial betterment. Incidental to the convention will be a unique exhibition devoted to various phases of industrial education with students actually at work in various lines of industries. In this will be included exhibits from New York City; Newark, N. J.; Fitchburg, Mass.; New Haven, Conn.; Altoona, Penn.; Detroit, Mich., and other places where well-known trade schools are established.

BOOKS RECEIVED

VALVES AND VALVE GEARS. Volume I. By F. D. Furman. John Wiley & Sons, Inc., New York. Cloth; 253 pages, 6x9¼ in.; 300 illustrations. Price, $2.50.

POWER HEATING AND VENTILATION. Part III. By Charles L. Hubbard. McGraw-Hill Book Co., New York. Cloth; 408 pages, 6x9¼ in.; 220 illustrations; tables. Price $3.

THE "PRACTICAL ENGINEER" POCKETBOOK AND DIARY FOR 1915. Distributed by the Magnolia Metal Co., New York. Cloth; 632 pages; 3½x5 in.; numerous illustrations and tables.

TRADE CATALOGS

Kerr Turbine Co., Wellsville, N. Y.—Bulletin No. 52. Economy turbo-pumps. Illustrated, 24 pp., 6x9 in.

Cresson-Morris Co., Philadelphia, Penn. Form No. 1001. Barometric condensers. Illustrated, 28 pp., 9x12 in.

The Richardson-Phenix Co., Milwaukee, Wis. Bulletin No. 40, Phenix oil and graphite cylinder lubricator. Illustrated, 4 pp., 8½x11 in.

The Draper Mfg. Co., Port Huron, Mich. Catalog No. 7. Valve facing tools, ball check valves, brass, iron and steel balls, pneumatic flue welders, pneumatic tube welders, etc. Illustrated, 40 pp., 6x9 in.

BUSINESS ITEMS

Negotiations were recently closed for the sale of the Cleveland Clutch Co. to the Reliance Gauge & Column Co., 5902-5912 Carnegie Ave., Cleveland, Ohio.

The contract for furnishing material under circular No. 891 for complete pumping plant for Dry Dock No. 1, Balboa Terminals, Balboa, C. Z., was awarded by the Panama Commission to Henry R. Worthington, 115 Broadway, New York.

August Mietz, 128 Mott St., New York, has recently secured orders for Mietz & Weiss oil engines from the Grinden Art Metal Co., of Brooklyn, N. Y. (2); the Town of Schleswig, Iowa (2); I. H. Pitts & Son, Waverly Hall, Ga.; Marcus Mason & Co., South Framingham, Mass.; George Buckley, Menlo, Iowa; U. S. Government, for lightships Nos. 101 and 102 (two 200-hp. direct reversible marine-type oil engines and four 50-hp. oil-engine air-compressor outfits).

NEW EQUIPMENT

ATLANTIC COAST STATES

The Cambridge Electric Light Co., Cambridge, Mass., has made application to the Board of Gas and Electric Light Commissioners for authority to issue $100,000 in additional capital stock, a part of which will be used for making additions to the system. W. E. Holmes, Newton, is Treas. and Gen. Mgr.

The Hudson Ice Co, 136 Oakland St., Jersey City, N. J., is preparing to build a 100-ton ice plant at Central and Jefferson Ave., Jersey City. S. H. McKnight is Pres.

It is reported that the Council has engaged W. S. Temple, Philadelphia, Penn., to prepare plans for the construction of a municipal electric-lighting system for Millville, N. J.

It is reported that the Town Council of Patton, Penn., is considering the establishment of a municipal electric-light plant. Service is now furnished by the Penn Central Light & Power Co., Altoona.

SOUTHERN STATES

It is reported that the Planters Oil Mill & Gin Co., Kosciusko, Miss., is in the market for additional power equipment and boilers.

The City of Oberlin, La., has appointed a special committee to engage an engineer to prepare plans for the construction of a municipal electric-light plant. W. D. Stockwell, Mayor, is Chn. of the Com.

CENTRAL STATES

The municipal electric-light plant at Ashley, Ind., was destroyed by fire recently at a loss of $4000. George W. Caryl is Mgr.

At a recent election in Chalmers, Ind., the citizens voted in favor of installing an electric-lighting system. It is reported that the plant will be constructed by a stock company, and will eventually be purchased by the town. T. C. Smith, Chalmers, is Engr.

The City Council, Lanark, Ill., is considering the establishment of a municipal electric-light plant.

It is reported that the Board of Public Works, Oshkosh, Wis., has been instructed to advertise for bids for a dynamo and connections for an independent lighting system for the new high school in Oshkosh.

WEST OF THE MISSISSIPPI

It is reported that the Iowa River Light & Power Co., Eldora, Iowa, contemplates spending about $50,000 for improvements to its system. A new power station will be built, and the output of the steam plant increased. J. C. Lundy is Mgr. and Cont. Agt.

The city of Shellsburg, Iowa is considering the question of establishing a municipal electric-lighting system. The estimated cost is $10,000. It is reported that the Cass Interurban Co. has also made an offer to build a transmission line from Urbana to furnish electrical service to Shellsburg.

The town of Marietta, Minn. is considering the question of establishing a municipal electric-lighting system.

The citizens of Kirwin, Kan., have voted in favor of a bond issue of $12,000 to be used for the installation of a municipal electric-light plant.

The town of Corder, Mo. has appropriated $6000 for the purpose of buying light and power equipment.

The city of Poplar Bluff, Mo., has voted $75,000 in bonds for the purpose of establishing a municipal electric-light plant. Contracts for the installation of the plant have been awarded.

L. B. Myers, El Reno, Okla., and associates, will establish, according to press reports, an electric-light and power plant and ice factory at North Pleasanton, Tex. The estimated cost is $40,000.

It is reported that the city of Seguin, Tex., will make improvements and extensions to the municipal light and power plant to include the construction of a new building and penstocks, the installation of a 187-kw., three-phase, 60-cycle, 2300-volt, waterwheel type generator, exciter and switchboards, two 150-hp. vertical waterwheels and transmission machinery. Owen A. Gofford is Mgr., Cont. Agt. and Supt. of the plant.

It is reported that Morris Sass, Ardmore, Okla., is in the market for power equipment, including a gasoline engine.

It is reported that the City Council of Reno, Nev., is considering a bond issue of $750,000 to be used for the construction of a municipal electric-light plant and water-works system. J. R. Parry is City Clk.

Bids will be received until May 28 by R. W. Davis, Mayor, Harrisburg, Ore., for one 35-hp. motor of 900 to 1300 r.p.m., one 25-hp. motor, 900 to 1200 r.p.m., and one 5-hp. motor of about 1500 r.p.m.

The City Trustees of Escondido, Calif., have decided to call a special election to vote on the question of a bond issue to be used for purchasing the property of the Escondido Utilities Co.

CANADA

It is reported that the city of Sherbrooke, Que., will purchase electric meters, controllers, etc., to the amount of about $27,000. W. E. C. Gatien is City Clk. No bids will be asked.

The Canadian Niagara Power Co., Niagara Falls, Ont., contemplates making extensive improvements in its plant. Philip P. Barton, Niagara Falls, is Gen. Mgr.

The City Council of Kelowna, B. C., is considering the establishment of a municipal electric-light plant, estimated to cost $120,000. It is reported that a bylaw will shortly be submitted to the rate-payers.

POWER

Vol. 41 — NEW YORK, JUNE 1, 1915 — No. 22

The Salesmen's Reply

BY WILLIAM A. DUNKLEY

An answer to "The Troubles of the Manager," in the March 30 issue.

We get our hot times here on Earth, then climb the "golden stair."

THE MANAGER'S a grouchy cuss, although he has it soft
And lounges in an easy chair and wears out good broadcloth
He has his car, he has his golf; these joys cannot allay
The grouch that grips his vitals when we boys come his way.
Outside his door an office boy confronts us with a frown
And says, "Come back some other time, the 'Old Man's out of town'
And if at last we pass the door and beard him in his lair,
He acts as though "Old Nick" himself would be more welcome there.

He sits and smokes our good cheroots (We buy them three for five),
And he is game to buy our goods in case he can survive.
We show him how to save his dough and how to spend it too.
He may have tried some other line, but ours is "something new."
We're agents of prosperity and keep him up to date,
And any plant without our goods would meet a sorry fate.

But when he gets to Satan's realm, he'll find no salesmen there.

Some time ago we met a chap who ran a power plant,
And every day he'd tear his hair, and cuss, and rave, and rant.
Directors had him going right, the dividends were slim,
And costs were soaring out of sight; looked like "good night" for him.
His durned old plant was out of date, and leaks were everywhere,
And here a groan and there a knock, were crying for repair.
He wasn't wise to boiler scale, much less to CO_2
And half his good bituminous was wasting up the flue.

We talked to him until our throats were parched as desert sand;
But "soda water" fixed us up (guess you will understand).
And finally, he was convinced and purchased half our line;
And now, that same old power plant is running something fine.

We are the manager's best friends, we help him to progress,
And steer him up the narrow path to honor and success.
And when at last he shuffles off, beyond the milky way.
We have a line of golden harps to make his future gay.
And if instead, he goes below in spite his good intent,
We'll lag him well with fireproof paint, asbestos and cement.
But when he gets to Satan's realm, he'll find no salesmen there;
We get our hot times here on Earth, then climb the "golden stair."

Power Plant of the Hughes Electric Co.

By C. P. Larsen

SYNOPSIS—This power plant supplies electrical energy for motor and lighting service and for operating the pumping plant. Exhaust steam is used for district steam heating. Lignite containing 6590 B.t.u. per lb. is used as a fuel. Burning 42 lb. of coal per square foot of grate area. 3 lb. of water is evaporated per square foot of boiler heating surface.

The power house of the Hughes Electric Co. supplies the town of Bismarck, N. D., with light, heat and power and also pumps the water for the Bismarck Water Supply Co. The boiler room, Fig. 1, contains four water-tube boilers, each rated at 306 hp., having 3060 sq.ft. of heating surface, and two return-tubular boilers, each rated at 150 hp. The boilers are hand-fired, as no stokers are known for burning lignite that will give as good results as are obtained with hand firing. Each furnace of the large boilers is equipped with 48 sq.ft. of grate surface, or one to each 63.75 sq.ft. of heating surface. The grates used are of the flat sawdust type, perforated with half-inch holes, which give about 20 per cent. air space. This does not conform with modern practice for burning low-grade fuel, as with an increased grate surface a boiler can be forced to a greater extent, but it is a question if the combustion will be so complete with a lignite fuel that is low in carbon and contains so much volatile matter that must be taken care of to obtain efficiency. With this ratio of grate to heating surface, 3 lb. of water is evaporated per square foot of heating surface and 42 lb. of coal is burned per square foot of grate surface.

Fig. 1. Boiler Room of the Hughes Electric Co.'s Power Plant

Lignite burns much like dead wood or brown paper, with a natural slow draft, and it can burn like a blacksmith's fire and give off very little heat. It will slack and turn into dust, and when fired under a boiler in this condition the design of grate is of importance, as with a 40 per cent. air space there is little chance for the fuel to rest while it burns, for it is in continual motion, rolling around and mixing with ashes, which results in a flameless fire. If the air pressure under the grates is increased, holes will be blown in the fuel bed through which air will pass freely and cool the furnace.

It is necessary to level off the bed of fire or fill the holes with a fresh supply of coal, but if the fire is in bad shape there is no remedy, and the only thing to do is to pull it and start a new one. With less air space the fuel has a chance to rest on the bridges between the holes and each hole will form a little burning jet, as a higher air pressure can be maintained under the grate. The greater the velocity of the air through the holes, the greater the increase in the temperature; about 1900 deg. is obtained and a flue-gas temperature of about 450 deg. F., with an average of 12 per cent. CO_2.

There is a peculiarity in burning lignite coal as it can be easily wasted owing to the amount of air required for combustion. The long flame, with its low temperature, carries the unignited gases through the boilers and up the smoke-stack and produces a deceiving temperature of flue gases. It is possible to burn 60 lb. of coal per square foot of grate surface and evaporate but 3 lb. of water per square foot of heating surface and have a flue-gas temperature of but 350 deg. F. Then again, it is possible to change the air supply, break the coal to suitable sizes, burn 35 lb. of coal per square foot of grate surface, evaporate the same amount of water per square foot of heating surface and have a flue-gas temperature of 450 deg. F., a decrease in fuel consumption of 41 per cent.

An average evaporation of 4.5 lb. for a month's run is obtained in many tests, and during short tests as high as 4.85 lb. of water per pound of coal has been evaporated; the temperature of the feed water being 190 deg. F., steam pressure 140 lb. and the coal containing 6590 B.t.u. This is equal to an evaporation of 8.8 lb. of water from and at 212 deg. F. per pound of combustible and shows an efficiency of about 77 per cent. These results are obtained by using forced draft with a slow velocity, so that the heat in passing through the boiler is absorbed by the water. It is not advisable to force a boiler above its normal rating. It is easy to force the fires and send a flame out at the top of a 50-ft. stack, but at the same time the boiler is not generating steam in proportion to the fuel burnt.

It is not an easy matter to lay down a general rule for burning lignite. The coal burned at this plant is a low-grade fuel containing about 6500 B.t.u., between 35 and 40 per cent. moisture and from 5 to 10 per cent. ash. It is not suitable for long shipments or storage in warm weather, as it slacks, or pulverizes, like burnt lime when it loses its moisture.

It is delivered to the power house in railway cars and unloaded into a bucket conveyor about 150 ft. long, extending 60 ft. outside of the building alongside the railroad track. Two cars can be unloaded at the same time. In the overhead run the conveyor is provided with chutes for each boiler. Its capacity is 25 tons per hour and it is driven by a 10-hp. motor. The cars on the side track are moved by a car puller driven by a 5-hp. motor.

The cost of handling the coal from the cars into the boiler room is 9c. per ton. The plant is 25 miles from the mine and the coal, which runs in size from 6-in and down to dust, costs $1.75 per ton delivered at the plant. Once in a while a car of slack is received, at $1.15 per ton, which helps to bring the average price of the fuel down.

The boiler room is 60x80 ft. and 30 ft. high. There are three steam-driven boiler-feed pumps, two vacuum pumps, one air compressor, one boiler-washing pump and one open feed-water heater. The last is merely a tank, and as the condensation from the heating system has at times a temperature of 165 deg. F., it is found to be more economical to turn the exhaust from the vacuum and boiler-feed pump into the heating system when live steam is required. Otherwise, it heats the feed water up to about 200 deg. F.

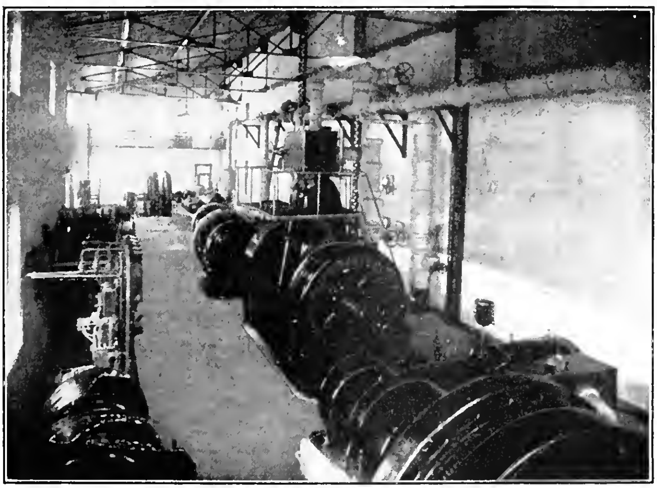


Fig. 2. General View of the Engine Room

A 30-in. fan for forced draft is driven by a 15-hp. motor. The air for this fan is taken from above the boilers and as it passes through the combustion chamber to the ashpit, it is warmed to some extent. The main boiler-feed pump has an 8-in. suction pipe and a 6-in. discharge, with 2.5-in. feed line to each boiler. The regulating valves are conveniently located; the steam pipe from the boilers to the 12-in. header is 6-in., equipped with automatic stop valves. All pipes, fittings and valves are extra heavy.

The engine room, Fig. 2, is 30x115 ft. and 25 ft. high; it is neatly finished, and contains only the generating units, exciter and switchboard. It has a terrazza floor with marble borders, and the side walls are wainscoted 5 ft. high with white enamel brick; the engine beds above the floor line are painted silver gray; across one end of the room is a balcony, where the chief engineer has his desk. A winding iron stairway leads to this balcony.

The engine room contains five units. The smallest is a 12x12-in. engine running 270 r.p.m., with a steam consumption of 28 lb. per i.hp.-hr., and is directly connected to a 75-kw., 230-volt, direct-current generator. Unit No. 2 is a 16x16-in. engine running 270 r.p.m., with a steam consumption of 28 lb. per i.hp.-hr., and is directly connected to a 100-kw., 230-volt, direct-current generator. Unit No. 3 is a 20x18-in. vertical engine running 200 r.p.m., with a steam consumption of 35 lb. per i.hp.-hr. and is directly connected to a 200-kw., alternating-current, 60-cycle, 2300-volt generator. Unit No. 4 is a 11¼&25x18-in. cross-compound engine running 200 r.p.m., and uses 22 lb. of steam per i.hp.-hr.; it is directly connected to a 250-kw., 60-cycle, 2300-volt alternating-current generator. This unit has its exciter on the main shaft. Unit No. 5, Fig. 3, recently installed, is a 23x30-in. engine running at 150 r.p.m., and uses 23 lb. of steam per i.hp.-hr.; it is directly connected to a 500-kw., 60-cycle, 2300-volt, alternating-current generator. This generator is excited by a 35-kw., 125-volt, direct-current generator driven by a 50-hp. induction motor. Switches are arranged so that either unit can be excited from the 35-kw. exciter. A motor-driven exciter is used for No. 3 unit, as the company furnishes either direct or alternating current to its customers. There is also a 100-kw. motor-generator set, and as this is usually generating direct current the power factor in the alternators is increased by having this synchronous motor in the circuit. The switchboard has fourteen marble panels and is equipped with voltage regulator for the alternating-current circuit, circuit-breakers, switches for the generators and transmission lines, voltmeters, ammeters and wattmeters, and synchronizing indicator. In the engine room is a 30-kw. constant-current transformer for city arc lights.

The plant has equipment sufficient to supply an ordinary city of 20,000 inhabitants with electricity. Bismarck has a population of 7000 and about thirteen years ago the company started an electric plant with a 50-kw. unit. The rapid growth of the city, however, has constantly made demand for more units. The rate charged for cooking service is 3.5c. per kw.-hr., for lighting service it is 10c. to 12.5c., and for power service the rate is according to the amount used, from 1.5c. up.

The company is operating the city pumping station located on the banks of the Missouri River. The water flows by gravity into a receiving well 12 ft. in diameter. From there the water is pumped to three reservoirs on a hill 200 ft. above the river. Each reservoir holds about one million gallons. A 13x16-in. triple-plunger pump, belt-driven by a 100-hp. induction motor was recently installed. The speed of the motor is 150 r.p.m. with a 26-in. diameter pulley; it is belted to a countershaft with a 70-in. diameter pulley, 22-in. face. A 20-in. double-ply leather belt is used, and the crankshaft is speeded down to 34 r.p.m. by cut gears. The plungers have a displacement of 935 gal. per min. and the water pumped is 926.5 gal. per min. This allows 8.5 gal. for slippage, or 0.9 per cent.; 46 kw. are recorded by the wattmeter at this load, and as the theoretical kilowatt consumption for lifting 926.5 gal. to an elevation of 200 ft. is 34.8, this gives a 6-in. connection to the feed-water heater, and a 12-in. main to the heating system. The condensation is returned to the heater by vacuum pumps. Central heating has proved so satisfactory that the demand for steam has increased more rapidly than the electrical output, and to such an extent that in cold weather about 60 per cent. of the total steam generated in the boilers passes through a reducing valve to the heating system. The rate for steam is 40c. per 1000 lb. All customers are charged on a meter basis.

Condensation from the mains and branches is trapped off where the pipe enters the customer's building. These bleeders trap off about 20 per cent. of the steam output from the boiler. In the 16-in. header is a 16-in. oil and steam separator, from which the condensation trapped off amounts to 12 per cent. The condensation from the

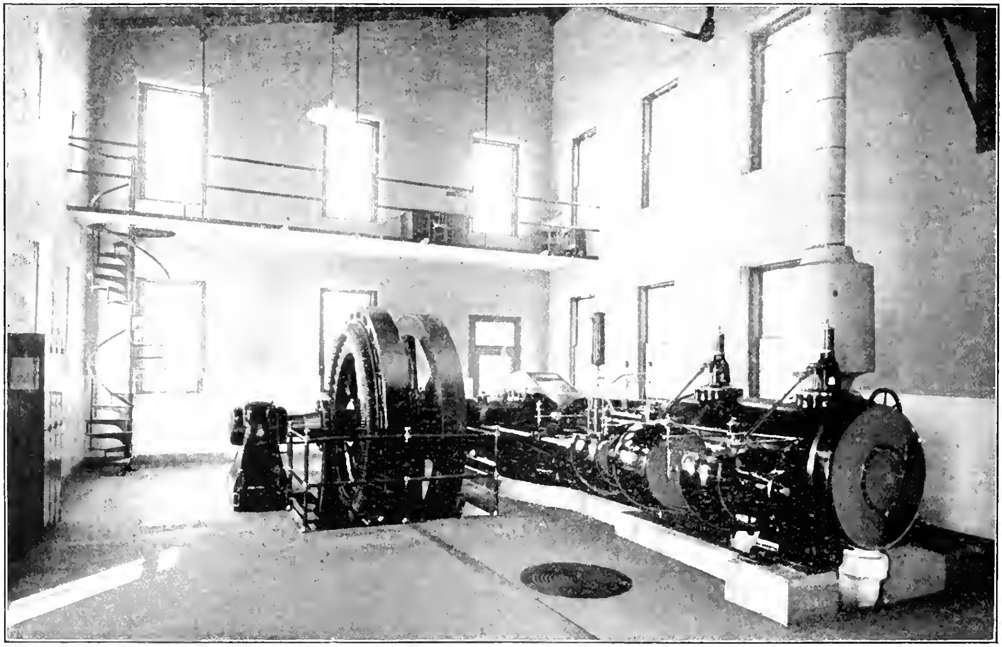


Fig. 3. The Latest Engine Installed Driving a 500-Kw. Alternating Generator

a combined efficiency of 75.7 per cent. for the motor and pump.

There is pumped 1208 gal. per kw.-hr. to an elevation of 200 ft., 13 ft. of this being suction lift. As the Nos. 4 and 5 units give the best steam efficiency, these are operated the most. With either, 8 lb. of lignite coal is burned per kilowatt generated and put into circuit; this includes steam for operating the boiler-feed pump and the vacuum pump for the heating system; also current for operating the forced-draft system, for the motor and for the station lighting. In summing up the combined efficiency of these units and the pump, it shows that one pound of this low-grade lignite coal is elevating 151 gal., or 1258 lb., of water 200 ft.

A central heating system is also operated. The exhaust pipes from the engines are connected to a 16-in. exhaust header, which has a 12-in. outlet to the atmosphere, high-pressure pipe line and receiver, steam separators and exhaust from the boiler-feed pumps, enters the open feed-water heater and amounts to about 4 per cent. The total of those items amounts to 36 per cent. of steam generated but not passing through meters. Those losses are not constant, as the percentage lost is less in cold weather with a greater steam consumption, though owing to these condensations the company receives only 27c. per 1000 lb. of steam generated; still, the output of steam for the month of December, 1914, made a favorable showing, as 9,844,000 lb. was recorded by the meters in the heating system and 3,444,400 lb. of coal was burnt during the month, at a cost of $2686.32, or $1.56 per ton. As during the winter months there are many sunshiny days with a comfortable temperature, considerable exhaust steam escapes to atmosphere during peak loads. This is a natural loss and cannot be controlled.

PRINCIPAL EQUIPMENT OF THE HUGHES ELECTRIC COMPANY'S POWER PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Franklin water-tube	306-hp.	Steam generators	Hand-fired, steam pressure, 140 lb.	Franklin Boiler Works Co.
2	Boilers	Return-tubular	150-hp.	Steam generators	Hand-fired, steam pressure, 130 lb.	Western Supply Co.
1	Blower	Sturtevant	30-in.	Forced draft	Motor-driven	B. F. Sturtevant Co.
1	Motor	Direct-current	15-hp.	Driving blower		General Electric Co.
1	Coal conveyor	Bucket	25 tons per hour.	Car and elevt coal.	Motor-driven	Link-Belt Co.
1	Motor	Direct-current	9-hp. inclosed	Driving coal conveyor	Intermittent	General Electric Co.
1	Pump	Outside-packed	14x9x16-in.	Boiler feed	140 lb. steam	Union Steam Pump Co.
1	Pump	Duplex	8x6x12-in.	Boiler feed	140 lb. steam	Dean Bros. Steam Pump Works
1	Pump	Duplex	7x5x10-in.	Boiler feed	140 lb. steam	Dean Bros. Steam Pump Works
1	Pump	Duplex	5x3½x8-in.	Boiler washing	140 lb. steam, as wanted	Geo. F. Blake Manufacturing Co.
2	Pumps	Duplex	7x9x10-in.	Returns from heating system	Winter months	Dean Bros. Steam Pump Works
1	Air compressor	Locomotive type	9x9x10-in.	Cleaning generators	Steam-driven	Westinghouse Air Brake Co.
1	Car mover	Geared down to drum	Two loaded cars.	Moving coal cars	Motor-driven	Link-Belt Co.
1	Motor	Direct-current	5-hp. inclosed	Driving car mover	230 volts	General Electric Co.
1	Engine	Simple horizontal	12x12-in., 125-hp.	Generator drive	140 lb. steam, 270 r.p.m.	American Engine & Electric Co.
1	Generator	Direct-current	75-kw.	Light and power	270 r.p.m., 230 volts	General Electric Co.
1	Engine	Simple horizontal	16x16-in., 160 hp.	Generator drive	140 lb. steam, 270 r.p.m.	American Engine & Electric Co.
1	Generator	Direct-current	100-kw.	Light and power	230 volts, 270 r.p.m.	General Electric Co.
1	Engine	Simple vertical	20x18-in., 300 hp.	Generator drive	140 lb. steam, 200 r.p.m.	Bates Machine Co.
1	Generator	Alternating-current	200-kw.	Light and power	60-cycle engine drive, 200 r.p.m., 3 phase, 60-cycle	General Electric Co.
1	Engine	Cross-compound, horizontal	14¼&25x18-in., 300 hp.	Generator drive	140 lb. steam, 200 r.p.m.	Buckeye Engine Co.
1	Generator	Alternating-current	250-kw.	Light and power	Three-phase, 60 cycle, 200 r.p.m.	General Electric Co.
1	Engine	Simple Lentz	23x30-in., 750-hp.	Generator drive	140 lb. steam, 150 r.p.m.	Erie City Iron Works
1	Generator	Alternating-current	500-kw	Light and power	Three-phase, 60-cycle, 2300 volts, 150 r.p.m.	General Electric Co.
1	Motor generator	Alternating- and direct-current	100-kw.	Light and power	Three-phase, 60-cycle, 2300 volts, 150 r.p.m.	General Electric Co.
1	Exciter	Motor-driven	35-kw., 125 v.	Exciting generator	Reversible	General Electric Co.
1	Motor	Induction	50-hp.	Exciter drive	Motor driven	General Electric Co.
1	Exciter	Motor-driven	11-kw., 125 v.	Exciting generator	60-cycle, 1200 r.p.m.	General Electric Co.
1	Motor	Induction	20-hp.	Exciter drive	Motor-driven	General Electric Co.
1	Exciter	On engine shaft	80-amp., 125 v.	Exciting generator	60-cycle, 900 r.p.m.	General Electric Co.
1	Transformer	Constant-current	30-kw., 2200 v.	Arc lights	Engine-driven	General Electric Co.

During the heating season there is no consideration given to an economical cutoff in the engine cylinder, as with a 50 per cent. cutoff the terminal pressure is about 60 lb., and as this volume passes into the heating system it gives a momentarily increased velocity 300 times a minute, which is noticeable all through the system, and for this reason good service has been given with as low as 2.5 lb. pressure at the power house.

Simplex condensation meters are used in the system, and steam traps are the standard traps in use where advisable.

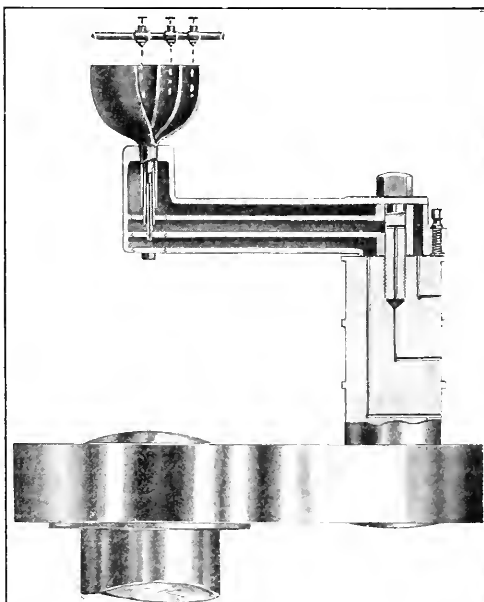
The output of electricity for the month of December, 1914, was 175,495 kw. Of this 25,000 was sent through a 6600-volt transmission line to a railroad shop five miles from the power house. This leaves 150,495 kw. for Bismarck with its 7000 inhabitants, or over 20 kw. for each person per month.

Central Oiler for Vertical Crankpin

Maintaining an adequate supply of oil on vertical crankpins has never been an easy problem, and when the pin carries two or perhaps three bearings, as in the case of angle-compound-centrifugal pumping units, the difficulties are increased.

As an easy solution to this problem Wm. W. Nugent & Co., of Chicago, are offering the central crankpin oiler shown in the accompanying illustration. It consists of a horizontal oiler arm and a funnel to receive the supply of oil. One end of the arm is secured to the crankpin by a bolt, and the receiving end is centered over the vertical shaft. It is evident that while the funnel revolves with the crankpin there is no lateral movement, so that the funnel will remain under the oil feed shown just above. Depending on the number of bearings on the crankpin, the central arm has one, two or three compartments fed through an equal number of concentric funnels.

In the illustration shown the pin has three bearings for the three connecting-rods of a triple-expansion engine. As a consequence there are three compartments in the arm and three funnels, one feeding to each compartment and each compartment feeding a bearing through oil holes



NUGENT OILER FOR A VERTICAL CRANKPIN

bored in the crankpin. By means of the open feeds above the funnels the supply of oil to each bearing can be regulated to suit requirements while the unit is in operation.

Feeding through the Blowoff Pipe—About the only excuse for feeding a boiler through the blowoff is that it helps keep the pipe clear. A circulating pipe connected outside of the setting will do as well and allow the boiler to be fed in a safe manner through an internal feed pipe.

Interior Wiring for Lighting and Power Service--V

By A. L. Cook

SYNOPSIS—Power panel-boards; the two-wire direct-current system, and single-phase, two-phase and three-phase systems for power. Full directions for calculating circuits are given, together with illustrative examples. The series concluded.

The choice as to the use of conduit or open wiring for power circuits in factories can be based upon the same considerations as were discussed in connection with the calculations of lighting circuits. If open wiring is to be used, it should be confined to the feeders, which can be located on the ceiling of the room, where they are not exposed to damage; and the branch circuits, which must run in more exposed places, should be placed in conduit. If a combination system of this kind is employed, a suitable bushing such as a condulet should be used at each end of the conduit, since an ordinary iron conduit bushing will not be approved by the inspector. This also applies to the end of the conduit at the motor and at the switchboard. The wire used is the same as for lighting service and is installed under the same rules.

Usually, the branch circuits for a group of motors can best be supplied from a common point at which a panel-board is located. Each branch circuit on the panel-board should be supplied with a knife switch and fuses. Sometimes a switch and fuses in the main busbars of the panel are also provided, but this is not necessary unless other subfeeders are supplied from the panel. Spare circuits should always be provided in every panel-board, the size and number depending upon the probable additions to the motor equipment.

For an installation of any size, one or more switchboard panels must be provided either at the service point or the power station. These panels should contain a circuit-breaker for each feeder and may or may not have a knife switch, depending upon the type of circuit-breaker used. If the board is under expert supervision, as in a power plant, fuses for each feeder may be omitted. The "Code" does not allow a fuse larger than 600 amp. for 250 volts or less, and 400 amp. for 550 volts; so circuits of larger capacity must be protected by circuit-breakers alone. For direct-current service, the carbon-break type of circuit-breaker with overload trip is satisfactory for most uses. For alternating-current service the carbon-breaker type is satisfactory for 110 or 220 volts, but for higher voltages an oil circuit-breaker is much better. For these high voltages it is difficult to get sufficient spacing on the switchboard between adjacent circuits to make the use of carbon circuit-breakers safe. The cost of the oil type is greater, but the resulting saving in the size of switchboard and the more satisfactory operation make its use desirable.

For power feeders it is always best to provide circuit-breakers of some kind rather than to use fuses only, because the fluctuations in load would result in great expense for replacing blown fuses if they were depended upon to open the circuit in all cases of overload. The first cost of the switchboard is, of course, greater, but the saving in replacing fuses and the ability to restore the service more promptly after an overload fully justifies the use of circuit-breakers, particularly in industrial establishments. They can often be used to advantage in protecting individual motors, and of course they must be used for loads exceeding the rating of the largest fuses. According to the "Code," if circuit-breakers are used for smaller loads, fuses must also be used unless the circuit-breakers are under expert supervision, as in a power house.

Two-Wire System

The method of laying out a two-wire system for power is similar to that for lighting. The usual arrangement would be similar to that shown in Figs. 8 and 9 (page 668, May 18, 1915), each panel-board supplying a number of motors. Usually, the two-wire system is employed for direct-current supply, the single-phase system, which also uses two wires, being suitable only for small motors. In the following, therefore, only the direct-current two-wire system will be considered. A two-wire supply for motors may be obtained from a three-wire system by connecting across the outside wires of the system. Sometimes the motors are run from the same feeders that supply the lights on a three-wire system, but this is not desirable because of the voltage fluctuations and greater liability of interruption; and it is therefore best to run separate power and lighting feeders from the supply point.

In locating the panel-boards and switchboards, the same considerations apply as for lighting service, already discussed. The size of wires for the individual motors may be obtained from Table 11 (page 703, May 25, 1915). This table does not take into account voltage drop, which should be calculated by means of the wiring chart, assuming full-load current on the motor. If the drop exceeds about 1.75 per cent. the size of wire should be increased. When the size of wire has been checked in this manner, the fuses for the branch circuit should be chosen, using Table 7 (page 642, May 11, 1915), and fusing to the full capacity of the wire, unless this fuse is the only protection for the motor, in which case 25 or 30 per cent. overload should be allowed.

The total connected load on each panel-board may be obtained by adding together the full current of all the motors on that panel, with a proper allowance for spare circuits. This result is then multiplied by the load factor, an estimate of which must be made carefully; in the absence of definite information 0.75 would be a fair figure to use. After the load has been calculated, the size of the feeder may be determined by reference to Table 7. The voltage drop with the given load should then be determined, and if it exceeds about 3.25 per cent., the size of wire should be increased. If the feeder supplies several panel-boards, or if the motors are connected to various points on the feeder, the drop should be calculated for each section separately and these values added to obtain the total drop. The size of fuses or the setting of the circuit-breakers on the feeders should be such as to allow the full current capacity of the wires in accordance with the values given in Table 7, irrespective of the actual loads on the feeders.

Three-Phase System

The three-phase system for power supply would employ three wires with equal voltages between them. The four-wire, three-phase system would not be used for motors, the neutral wire being used only when lighting is to be supplied. Ordinarily, three-phase motors requiring three leads would be used, although small single-phase motors might be run from a three-phase system by connecting them across one of the phases. The general arrangement of the branch circuits and feeders would be similar to that for direct-current. Because of the higher voltages which may be used, however, the branches may be made longer and the number of panel-boards thereby decreased.

The sizes of the branch circuits for individual motors are given in Table 12 (page 703, May 25, 1915), which applies to squirrel-cage motors. If motors of the wound-rotor type are employed, the wire should be made large enough to carry at least 1.5 times full-load current, using column A or B of Table 7 (page 612, May 11, 1915), to determine the size. In this case the starting current would be only slightly greater than the full-load running current, consequently fuses selected to protect the branch circuits would also protect the motor, so that the so-called "running fuses" used for squirrel-cage motors could be omitted. All three of the wires should be of the same size, as the currents are equal in all of them.

Table 12 takes no account of the drop in voltage on the wires, therefore this should be checked. If a drop of 1.75 per cent. is allowed between terminals of the motor, as previously specified, a drop of 0.58 of this value, or 1 per cent., can be allowed in each wire. After figuring the direct-current drop for one wire, calculate the alternating-current drop by the method previously described. Take, for example, a 50-hp., 440-volt, 60-cycle, three-phase motor. From Table 12 it will be found that the size of wire should be at least No. 0. The full-load current is 61 amp. If the length of the branch were 100 ft., the direct-current drop would be 1.24 volts for two wires, or 0.62 volt for one wire. Assuming that the wiring is in conduit, it will be found from Table 14 (page 705, May 25, 1915) that the ratio of reactance to resistance is 0.38. With a power factor of 0.85 (see Table 15) the drop factor is 1.07; hence, the alternating-current drop per wire would be $1.07 \times 0.62 = 0.66$ volt, and the total drop, $1.73 \times 0.66 = 1.14$ volts. This is only $\frac{1.14}{440} = 0.002$, or 0.2 per cent., which is much below the maximum of 1.75 per cent. allowed for the branch drop. In this case, therefore, the size of wire is taken as No. 0 because it is the smallest wire which will carry the current safely. If it had been found that the drop was greater than 1.75 per cent., the wire size would be increased as required.

In determining the total load on a panel-board, it is necessary to estimate the maximum load which would have to be supplied at any particular time. As previously explained, this would generally be less than the sum of the full-load currents of all the motors supplied from the panel. With squirrel-cage induction motors care should be taken that the wire is large enough to carry the starting current of the largest motor together with the normal running current of the others. For example, suppose a panel-board supplies the following motors:

One 15 -hp., 220-volt	38.6 amp. full load
One 5 -hp., 220-volt	13.4 amp. full load
One 7.5-hp., 220-volt	19.6 amp. full load
One 10 -hp., 220-volt	26.6 amp. full load
Total	98.2 amp. full load

Suppose that, from a knowledge of the operating conditions, the load factor can be taken at 0.75; the maximum current would then be $0.75 \times 98.2 = 73.6$ amp. There is also a 20-hp. motor supplied by this panel-board, which, when starting, takes 158 amp. The total is the combination of the running current of the several motors and starting current of the 20-hp. motor. The running currents are, however, at a power factor of 0.80 and the starting current at a power factor of about 0.50, hence, they cannot be added together directly; in fact, the total current is less than the sum of these two currents. To add these currents, we have to divide each into a "reactive" part and a "resistance" part by multiplying by the proper factor. The values of these factors for the usual power factors are as follows:

TABLE 16—REACTIVE AND RESISTANCE FACTORS

Power Factor	Reactive Factor	Resistance Factor
1.00	0	1.00
0.95	0.31	0.95
0.90	0.44	0.90
0.85	0.53	0.85
0.80	0.60	0.80
0.75	0.66	0.75
0.70	0.71	0.70
0.65	0.76	0.65
0.60	0.80	0.60
0.55	0.84	0.55
0.50	0.87	0.50
0.45	0.89	0.45
0.40	0.92	0.40

Applying these factors to the example,

Resistance Factor	Reactive Factor
$73.6 \times 0.80 = 59$	$73.6 \times 0.60 = 44.2$
$158 \times 0.50 = 79$	$158 \times 0.87 = 137.5$
138	181.7

The total current is $\sqrt{(138)^2 + (181.7)^2} = 228.2$ amp.

From Table 7 it will be seen that a No. 00 wire would probably be sufficient. If the two currents were added in the usual way the result would be 231.6 amp., which in this case would approximate closely the total current. The nearer alike the power factors of the two currents, the less need there is for employing the exact method given above.

The arrangement of feeders and subfeeders supplying the panel-boards may be laid out in the manner already described. Usually, there will be two or three panel-boards supplied from one feeder, but the number will depend upon the size of the motors and their location. It is desirable to keep the number of feeders a minimum, and on the other hand, it is not wise to use excessively large feeders, because of the great voltage drop. In general, the use of a feeder larger than 300,000 circ. mils is not justified when alternating current is used. The drop on the feeder should be calculated in a manner similar to that employed for the branch circuits, as has already been explained. The current to be used should be the maximum-load current, which is calculated by multiplying the sum of the full-load currents of all the motors (including an allowance for the spare circuits on the panel-board) by the proper load factor. When a motor is starting there will be a larger voltage drop, but this occurs only for a brief period and can generally be neglected if there are a number of motors on the feeder. When squirrel-cage induction motors are starting the current is large and the power-factor is about 0.50. There would therefore be momentarily a very large drop if the motor starting is large as compared with the other motors. An approximate value of this drop can be determined by neglecting the drop due to the motors running, and calculating the drop for the motor starting alone. The actual drop would then be somewhat greater than this owing to the current taken by the motors running, but would be less than the sum of these two drops. The reason for this is that we have a different power-factor for the running motors and the motor starting, and therefore, the total drop is less than the sum of the two drops.

Two-Phase System

Either the four-wire or the three-wire, two-phase system may be used. If the four-wire system is used, the two windings of the motor are connected across the two phases of the supply; with the three-wire arrangement, the windings of the motor are connected between the outside wires and the common wire. Care must be taken that neither of the windings is connected across the outside wires, as this would subject the winding to an excessive voltage. If the motors are provided with three terminals, the common terminal must always be connected to the common wire. If the direction of rotation is to be changed, this should be done by reversing the connections to the outside lines, keeping the common lead connected to the common wire of the system. If a motor having four terminals is to be connected to a three-wire, two-phase system, the two windings of the motor must be identified, by testing if necessary, and then one terminal of each winding must be connected to the common wire. The three-wire, two-phase system is commonly used, because of the saving in the cost of the circuits. The relative values of voltage and current in the various leads of the two-phase systems have already been explained in connection with the calculations of lighting circuits, and the length and general arrangement of the branch circuits are governed by the same general rules as were given for the other systems.

In Table 13 is given the full-load current and the minimum wire size for two-phase, four-phase, squirrel-cage induction motors, the current given being the value for each of the four wires; the size of wire also refers to each of the four wires. If a three-wire, two-phase system is used the currents in the outside wires and the sizes of these wires are as given in the table, while the current in the common wire is 1.42 times that given and hence the size of this common wire must be increased proportionately. For example, assume a 50-hp., 220-volt, two-phase motor, with a four-wire system; the size of each of the four wires would be No. 0000 and the full-load current 105 amp. With a three-wire, two-phase system the two outside wires would be No. 0000 and each would also carry a current of 105 amp. at full load. When starting, the current in the outside wires is 2.9 × 105 = 305 amp., which requires a No. 0000 wire, as given in the table. The starting current in the common wire, however, is 305 × 1.42 = 434 amp., and from Table 7, a 400,000-circ.mil wire will be found necessary.

If the wound-rotor type of motor is used, the wire should be sufficient to carry at least 50 per cent. overload continuously. Hence, in the case of this 50-hp. motor the current would be 1.50 × 105 = 158 amp. If four rubber-covered wires are used they should each be No. 000, and if three wires are used the outside wires should be No. 000. The maximum current in the common wire would be 158 × 1.42 = 224 amp., which would require a No. 0000 wire. In the case of squirrel-cage motors running fuses are required; that for the common lead having a capacity about 1.42 times that for the outside leads.

In the foregoing no account has been taken of the voltage drop, the size of wire given in Table 13 being the minimum size that should be used. It frequently happens that the voltage drop for the branches is small for either three-phase or two-phase systems because of the high voltages used. In any case, however, where there is a possibility of the drop being excessive, calculations of this should be made. In a four-wire system, since the two phases are independent, calculate the circuit as if it were a two-wire, single-phase system, and calculations need be made only for one phase. The drop on one phase can first be calculated by means of the direct-current chart and then the proper correction made for alternating-current by means of Tables 14 and 15. The allowable percentage drop in the branch circuits is about 1.75 per cent. for each phase. For example, take the 50-hp. squirrel-cage motor already mentioned. Assume a frequency of 60 cycles, a power factor of 0.85 and a length of branch circuit of 200 ft. Assuming a four-wire system, the smallest-sized wire which can be used is No. 0000 and the full-load current is 105 amp. Hence, the direct-current drop on one phase would be 2.1 volts. If the wires are in conduit the ratio, from Table 14, is 0.76 and the drop factor is given in Table 15 as 1.27. Therefore, the alternating-current drop is 1.27 × 2.1 = 2.67 volts. This is 2.67 ÷ 220 = 1.2 per cent., and the size of wire is satisfactory.

If a three-wire system were used, the drop would be calculated as follows: The current in each outside wire would be the same as before, namely, 105 amp. Hence, the drop in each of the outside wires would be 1.05 volts, from the direct-current chart. With alternating current, the drop in each outside wire would be one-half that previously found, or 1.34 volts. Since the curreuts in both outside wires are the same, the current in the common wire is 1.42 × 105 = 149 amp. under full-load conditions. It has already been found that the minimum size of this wire is 400,000 circ.mils, and the direct-current drop for this wire, with 149 amp. flowing, is given by the chart as 0.8 volt. For alternating current, the ratio in Table 14 is 1.49 and the drop factor 1.67 from Table 15. Hence, the drop on this wire is 1.67 × 0.8 = 1.34 volts. The total drop on one phase is $\sqrt{1.34^2 + 1.34^2} = 1.9$ volts or 0.9 per cent., which shows the sizes chosen to be correct.

In finding the total load on the panel-board the methods described under the three-phase system should be employed, using the proper load factor and allowing for the starting-current. The drop in the wires may be calculated by the rules given for the branches, since in all cases the loads are balanced. The same rules regarding the combination of currents at different power factors apply.

Increasing Boiler Capacity

By Joseph Harrington

SYNOPSIS—Stirling boiler furnace equipped with Roney stoker remodeled so that the capacity of the boiler was increased from 130 to 309 per cent. of rating. Attention to the dampers increased the draft over the fire. An extension of the furnace arches and the stopping of needless poking of the fire obviated dense smoke.

Having had occasion recently to overhaul a plant for the combined purpose of increasing capacity and decreasing smoke, the results obtained may be of interest to Power readers. The plant in question consists on its steam-generating side of 500-hp. Stirling boilers equipped with Roney stokers having 105 sq.ft. of grate surface. Two 175-ft. stacks serve the two lines of boilers through straight breechings of ample proportions.

This plant had not only been making objectionable smoke, but it was not possible to get from it much more than the boiler rating. Preliminary tests under the former operating conditions gave but 650 hp., or 130 per cent. of rating. These unsatisfactory results were partly the fault of the initial design and partly the result of defective stoker conditions and operation.

As in the majority of smoke problems, this one was founded on the insufficiency of the draft. When the furnace draft was brought up to the point corresponding to normal conditions, combustion was noticeably affected. The actual increase was about 50 per cent., or from 0.33

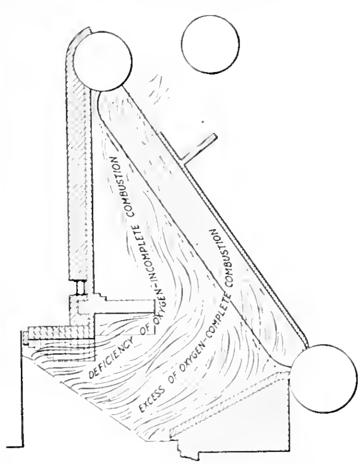


Fig. 1. Diagrammatic Analysis of Original Conditions

to 0.48 in., which under these conditions meant a radical difference in the furnace efficiency.

A part of the draft loss was due to a large damper in the main breeching near the stack. This was originally intended to be operated by a damper regulator, but had fallen into disuse and, although left wide open, was responsible for considerable interference with the gas flow. Its removal was a benefit, and owing to the slight friction loss in the breeching the stack draft was approximated at the boiler dampers. Dampering is usually overdone or underdone, and its influence for good or evil is still but little recognized. With the writer the conviction is gaining that a main breeching damper

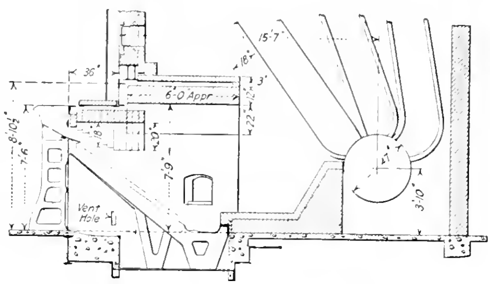


Fig. 2. The Remodeled Furnace

should be used only in certain special cases which must be selected with discretion.

Another heavy loss was chargeable to dampers, only this time it was the individual boiler dampers. Like the majority, these dampers did not close tight enough to exclude air leakage through the cold boilers. This was heavy, and the resultant volume of gases and infiltrated air was so great as to overload the stack. Temperatures were affected and the friction loss increased so that nothing like normal draft intensities were reached until this infiltration was stopped. Some day the idea of having airtight boiler dampers will be seriously proposed and find many advocates.

Sufficient draft in the furnace having been acquired, it was necessary to see that the furnace itself was able to take care of the increased volume of gases evolved at the higher capacities. An analysis of the furnace conditions is shown in Fig. 1. The cause of the smoke is apparent at a glance. Much of the volatile matter was slipping around the end of the short arch, across the chamber above, to the upper end of the first bank of tubes. The heavy excess of air at the lower end of the fire was filling the flame spaces of the front bank and holding away the hot gases that might otherwise have come into contact with the tubes. At the upper end of the furnace, temperatures were so far down that further combustion was impossible. The rest of the story was readable at the top of the stack.

Just as the cause became apparent, the remedy was obvious. In Fig. 2 is shown the furnace designed for this case. Extended comment is unnecessary. A more liberal supply of air was provided under the Roney arch and the proper fuel-bed thickness for different ratings was determined.

An important item was the handling of the stoker. The men seemed to think that the more they poked the better they did. This was all changed and the stoker allowed to do the work. Intelligent and effective coöperation on the part of the chief engineer resulted in the development of skilled firing, with less distress to the men and far better results from the stoker. It became apparent immediately that the stoker would do the work if left alone, and today it is the practice to poke only when there is special reason for it. Poking is done locally and as little as may be required to trim the fires in that particular spot.

Capacities up to 213 per cent. of rating were obtained for eight-hour periods, with an average increase in efficiency of 8 per cent. The highest hour showed 1545 hp., or 309 per cent. of rating. This was done without any injury to the stoker or furnace and without objectionable smoke. Furnace temperatures naturally were high, owing to the high rate of combustion and the reduction in excess air. On the high rating test an average of 13.17 per cent. CO_2 was obtained at the end of the flame and 11.96 per cent. at the damper. Moreover, practically all of the combustion took place in the *furnace*, which besides producing a high temperature was favorable to the absorption of the heat, the completely burned gases sweeping over the entire heating surface. The damper draft was 1.28 in. and the furnace draft 0.578 in.

While reference was just made to the highest capacity test of the series, the average was well above double rating. To give a better idea of the principal results, a table containing some of the averages is appended.

SUMMARY OF PRINCIPAL RESULTS

Test No.	Uptake Draft, In. of Water	Fur. Draft, In. of Water	Flue Temp., Deg F	Coal per Sq Ft. of Grate	Capacity, Hp.	Evap. F. and A as Fired, Lb.	Per Cent. Excess Air	Fur. and Grate Eff.	Combined Efficiency
4	0.881	0.451	728.53	39.46	1039.2	8.654	83.0	93.3	77.30
5	0.885	0.447	663.20	48.70	1039.0	7.010	65.0	89.6	63.36
6	0.936	0.447	694.30	47.96	1080.0	7.408	67.0	90.2	66.90
7	0.619	0.313	677.22	46.40	1076.9	7.621	65.3	84.6	64.40
8	0.702	0.356	741.25	43.36	944.0	7.400	54.5	87.8	68.30
9	1.280	0.578	747.20	55.70	1188.0	6.774	66.5	88.3	61.90
10	0.891	0.449	733.60	53.57	1214.1	7.446	42.0	93.0	65.18

Preventing Corrosion From Electrolytic Action

To prevent the electrolytic corrosion of boilers and similar vessels, the Cumberland Engineering Co., of London, Eng., has developed a rather interesting apparatus. Essentially, it consists of anodes that are insulated, that is, connected to the boiler shell by an insulated bolt, and that form the positive side of the circuit, while the shell itself is connected to the negative side, making it the cathode. The aim is to pass low-tension current, which may be regulated by resistances fixed on a switchboard or similar place. The current is supplied at from 6 to 10 volts, and an ammeter mounted on the board enables the operator to tell how much current he is sending through.

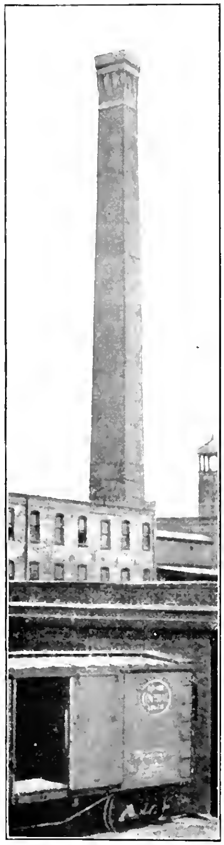
The elements of the water contained in the vessel are electrically charged when the current is on, and at the anodes there assemble the anions. When this occurs a film of hydrogen is said to form over the immersed portion of the vessel, thus protecting the latter; the oxygen, acid and other corrosive agents being attracted to the iron anodes, which become reduced just as zinc slabs do and must be renewed.

The claim is made that hydrogen, in being liberated from the surface of the metal in bubble form, tends to take from the surface any scale or other matter that may be clinging to it. This claim, then, presupposes that water must get under the scale, for the hydrogen bubbles must have their source in the water and not in the metal.

The development of this elaboration on the zinc-plate method of combating corrosion will be watched with interest.

A Brick Chimney Which Floats

In 1884 the Schlichter Jute Cordage Co., of Frankford Junction, Penn., started to put up a 200-ft. brick chimney, when it was found that the ground upon which the chimney was to stand overlay a quicksand into which a 3/8-in. iron rod would settle, if released, beyond hope of recovery. Mr. Herman Dock, to whom the design and construction of the chimney had been intrusted, simply cast a block of cement 30 ft. square and 5 ft. in thickness in an excavation, where it was desired that the chimney should stand, and built the chimney upon this floating block without any piling or other support. The chimney is square, as shown in the accompanying photograph, 13 ft. at the base and 11 ft. 6 in. at the top, and is composed of solid masonry without any core, the internal dimensions being 6 ft. at the bottom, and, contrary to the usual practice, 6 in. greater at the top. Its height is about 200 ft. and its total weight something like 1000 tons. It sways freely in the wind, and its movement may be felt by putting the hand between it and the engine-room wall, but it has suffered no permanent departure from the vertical. Four hundred barrels of Portland cement were used in casting the floating base; 1200 hp. of boilers are attached.



THE FLOATING CHIMNEY

Steam Consumption in Pumping—The common type of direct-acting pump, so much employed in mining, is well known to be wasteful in respect to the consumption of steam. This is owing to the necessity of using steam at full pressure throughout the entire length of stroke. Only a comparatively few pumps are designed to use steam expansively and these are not adapted to the commonly high lifts in mining. Steam consumption, in pumping, ranges from 10 or 15 lb. per i.hp. per hr., in triplex, flywheel pumps when run condensing, to an average of 150 lb. per i.hp. per hr. in direct-acting pumps. The consumption of steam, in pumps of the latter type, varies from 100 to 200 lb. per hp. per hr., depending on the speed of the pump and its condition. In this class of pumps, the consumption of steam is less as the speed is increased.—"Coal Age."

Some Notes on Elevator Pumps

By Thomas J. Rogers

The pump or pumps used in connection with a hydraulic elevator system should be of sufficient capacity to deliver the maximum quantity of water required promptly on demand. There are times during the day when the elevator system is heavily and quickly loaded and the water required is considerably more than the average quantity per minute pumped during the rest of the day. A pump large enough to care for these rush periods at a slow speed would, of course, be uneconomical during light-load periods. A common practice is to have a relay pump which may be run together with the main pump when the quantity of water required exceeds the capacity of one unit.

The crank and flywheel pumping engine for large elevator installations is superior in steam economy to other types, but is not available in small units, because it cannot be stopped and started automatically; and if kept running constantly it will pump through a bypass part of the time and much of the possible economy will be lost.

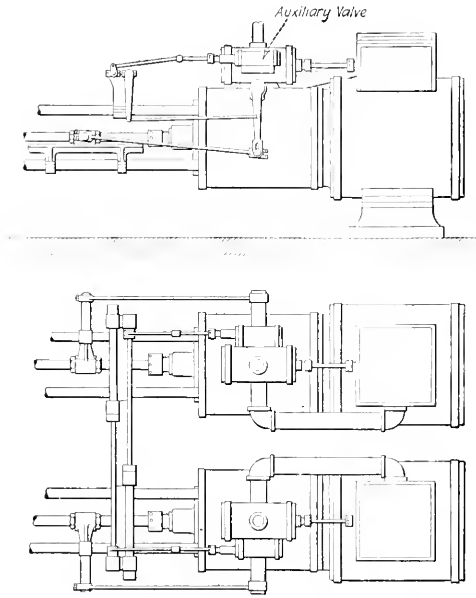
The writer has obtained good results with a compound separable duplex pump, in which either side may be operated independently of the other or both run together in duplex. This machine can be operated intermittently according to the demands of the service, and it is under governor control; it can be stopped when the proper pressure has been established and there is no demand for water, and started quickly when a slight drop in pressure occurs in the tanks due to the operation of the cars. When running duplex each of the two steam ends has control of the closure of its own steam valves, and the opening of them is controlled by the opposite engine.

The stroke is long and constant and the valve area large, though each valve is of small diameter. This type of pump closely approaches the economy of the crank and flywheel pumping engine, requires less attention, and the cost of operation and repairs is so much less than for the crank and flywheel type that, considering first cost, cost of foundations and installations, it is quite as economical an installation. It has the further advantage that it can be run either duplex or simple, one side only being operated during the periods of minimum demand, such as for night service, Sundays and holidays. This feature is particularly convenient when it is necessary to examine the piston packing, valves, etc., or when making examination or repairs to the steam end, as one side may be operated while such work is being done to the other side. This, of course, is impossible with the ordinary duplex pump or the crank and flywheel engine.

The maximum economy of any steam engine is obtained only when it is running at its full normal speed. In the case of a duplex or a crank and flywheel pump operating during the periods of minimum demand, the engine is necessarily run much below this speed; but in the case of the separable duplex type described, one side is shut down and the other operated at its full normal speed, meeting only the decreased demand.

On the steam end the method of connecting up is simple. It is well to use one valve in the main steam line and one in each of the branches, the exhausts being brought out and connected together in the most convenient manner to suit the situation. The side elevation shows the auxiliary steam chest and the control valve fitted to the side of the main steam chest, and by means of which the proper "timing" or duplex action of the two pumps is secured by movement of the piston in this auxiliary chest through the duplex levers and rods shown. Working duplex, this machine operates positively and is a true duplex, but not subject to short-stroking. Throwing the pump in or out of duplex is the work of but a minute, requiring only the pushing in of the handles of the control valve on the auxiliary chest on both sides to throw the pump into duplex running, or throwing them out of duplex by merely pulling these handles out.

When the pump is running as a duplex machine and it is desired to shut down one side, both handles are pulled out, leaving the pumps running for the minute as two separate units, then by shutting the valves on one side



Elevation and Plan of Elevator Pump

that pump is cut out, while the other side continues to operate as a single-cylinder, double-acting pump.

The water end should be fitted with two valves next to the cylinders which should connect to the main pump discharge through a tee. In case of running one side and opening the other cylinder for repairs, renewal of valves, etc., the closing of the valve next to the cylinder out of commission would isolate that one on the discharge side. The suction may have two separate lines at the pump.

In fitting an elevator pump, no matter what type, it is well to put relief valves on the water cylinders so that if by any chance the pump should be started with the stop valve in the main discharge line closed, excessive pressure will not be created in the pump cylinders. In such cases the relief valves usually discharge into the surge or the suction tanks.

Pumps used for delivering water up to about 250 lb. pressure into a closed tank, as on hydraulic-elevator systems under air pressure, are usually controlled by a pump pressure regulator. Where the pressure carried is above 250 lb. and up to an exceedingly high pressure an accumulator is used to govern the speed of the pumps.

Owing to the nature of the service being intermittent, the water on the suction side should flow to the pump by gravity with a head of from four to five feet over the under side of the discharge valves.

A necessary fitting to the water end of a hydraulic elevator pump is a suction air chamber. While the machine is in operation the water is rushing into the pump with considerable force, and should the regulator act and the machine stop at the end of its stroke, the water will continue to rush in with force enough to raise the suction valves from their seats and allow them to fall back with a loud pound. The pump air chamber prevents this.

The discharge air chamber should be kept at least three-quarters filled with air under pressure, and by application of a gage-glass its contents can be seen at a glance. A good method of recharging the discharge air chamber with air, should it become filled with water, is to run a line from the top of the air chamber to an air compressor with a check valve in the line close to the air chamber. If an air compressor is not available the best way is to attach an aërating valve in the suction line between the suction valve and the pump, and by running with this valve open to the atmosphere and the suction valve closed or partly closed, the machine will draw in air and force it into the discharge air chamber.

Motors to Put Engines Out of Business

By Bill B. Banger

SYNOPSIS—The alarming prospect revealed by the clipping (and it is an actual one that is reproduced) from the Eureka ——————. What it really shows is central-station enterprise.

While I was loafin' around my engin' room th' other day a feller blew in and started to look over th' shebang. He seemed mighty interested in th' generators, peeked into 'em here and there until I began to fear it would be necessary to send for an ambulance or an undertaker.

"Mr. Banger," said he after a spell, and I pretty nigh lost my equilibrium, seein' it's so long since I was called anythin' but Bill, except by th' firemen, who call me most anythin'. "Mr. Banger," says he, "this electricity stuff is all to th' futurity; you and I may not live to see any particular progress along electrical endeavors, but it will come, it's sure to come!"

I hadn't given th' feller much attention more'n to see he didn't get electricuted or fall into th' flywheel or some such minor accident, but his remarks made me hesitate in th' even tenor of my ways and squint at him over th' top of my glasses, which I have to wear on special occasions. A man with such broad perception of th' general trend of things, especially along electrical lines, was worth lookin' at a second time, by heck. Somehow or other, I had got th' idea that some considerable progress had been made in th' electrical generation and transmission of power and was somewhat surprised to hear that it wasn't likely that th' stranger and myself wasn't liable to live to see any material progress in electrical matters, leastwise not of a startling nature. Seein' I didn't have anythin' to say, I kept my mouth shut for once and waited for the next spasm.

"You'll be surprised, Mr. Banger," said he, "to see how electrical matters are progressin' in our town of Eureka. Of course, we don't come up to New York, but when you compare th' difference in size we are a close second, and lots of people are beginnin' to tumble to th' fact that we are on th' map. Of course, our trolley service ain't as big as what you have in this here city, but we get there just th' same.

"And our great white way is some class, I can tell you. One big electric light in front of th' grocery store and two in front of th' movin' picture sho', all on th' main street. Some town, I tell you."

Before I had a chance to say anything he started off again until I thought he was wound up for good. "I'll tell you, electricity is goin' to work havoc with th' steam and gas engin's and I can prove it." Whereupon he pulled out a newspaper clippin' and handed it to me to read. Here is what it said: [A reproduction of the clipping is shown herewith.—Editor.]

WILL USE ELECTRIC POWER.

Two Large Eureka Institutions Will Use New Power.

Electricity is rapidly replacing steam and gasoline engines as a means of power. The Eureka Roller Mills has placed an order with the Eureka Light and Power Company for a 20 horse power motor. This large motor will soon be here and will be given a thorough tryout by the milling company. As soon as the motor has proven to the satisfaction of the manager that it will do the work expected of it, the engine now used will be discarded.

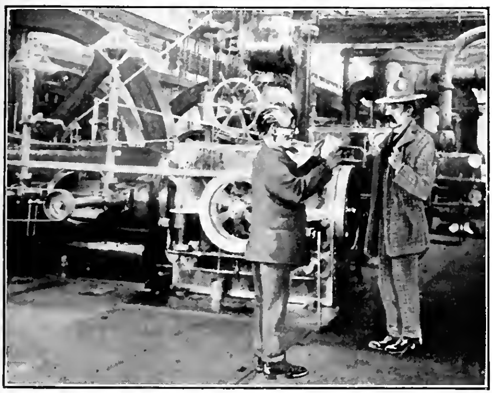
The Home Steam Laundry will install five electric motors. These are now here and will be connected up in a few days. This order consists of five motors—two 5-horse, two 2-horse and one on-half horse. These five motors will do the work now done by a steam engine and are supposed to be much more economical. The steam engine, however, will be retained in order to furnish steam and hot water for laundry purposes.

Well, I swan! When I finished readin' that clippin' I felt like putty nigh goin' over in a heap on th' engin' room floor. Just to think of a large 20-hp. motor bein' given a tryout to see if it would act satisfactorily! If th' motor does come up to th' scratch—and I calculate that there might be some doubts about it, seein' it's such a monster—I suppose th' large 20-hp. steam engin' what has been runnin' th' mill will have to go.

My visitor said there wasn't any more progressive parties in th' town than th' mill and th' laundry people, but I wondered how th' laundry people figures th' thing out that th' 15½ hp. in motors was goin' to be a gain, when they were goin' to keep th' old boiler—no it's th' engine—to furnish steam and hot water for laundry purposes.

It looks to me as if th' roller mill and laundry people wern't th' only ones that had their eyes peeled. It seems somewhat like as if the central-station evil, as it's sometimes called, was abroad in th' midst of Eureka and that th' business solicitor was a feller what was on to his job.

When I finished readin' th' clippin' Mr. Man was standin' with his thumbs in th' armholes of his vest, and



I SWAN! WHEN I FINISHED READIN' THAT CLIPPIN' I PRETTY NIGH FELL INTO A HEAP ON TH' ENGIN'-ROOM FLOOR

was teterin' back and forth on his toes and heels like a circus performer, and lookin' prouder nor a pussy cat with a litter of little toms.

"Some units," says he, "and it all goes to show that our people are awake to th' savin' what can be had by usin' electricity."

"That's as may be," says I. "Of course, I don't know how old that 20-hp. engin' is or how much steam it chews up per horsepower developed, which might be from 17 or 18 up to 60 or 70 lb. per horsepower, it all depends on th' engin' and th' engineer what has been nursin' th' thing.

"If th' engineer at th' mill is goin' to be kicked out in th' cold and th' steam plant shut down, and if th' charge for electrical energy is low enough and if th' steam engin' was a steam eater, why there is a chance—mind, I say a chance—that th' mill people will come out at th' big end of th' horn. If th' engin' is a good one and th' engineer knows his business, and if th' cost of juice ain't right, then I would advise them mill fellers to keep cool and not be in a hurry to threw th' engin' and boiler out onto th' scrap heap. They might be glad to start 'em up again when th' contract with th' electric company runs out," says I.

Th' stranger kinder looked stalled awhile and said he didn't think any mistake had been made and that even if it did cost more to run th' mill by motor than by steam, it didn't matter much, but showed that they were progressive anyhow. "Don't you know that th' introduction of all new innovations is prone to result in financial losses, more or less?" says he.

"Well," says I, "there is somethin' in what you say and so we'll let th' mill proposition drop and take a whack at th' wash factory. Accordin' to th' clippin' th' boiler—no th' engin' but we'll assume it's th' boiler—is to be hung onto and kept in th' business. It will take just as many men to run that boiler for keepin' up steam and heatin' water as it did to run th' boiler and th' 15½-hp. engin'. Th' only difference in th' operatin' cost will be in th' savin' of fuel that was necessary to burn to keep th' engine' goin', and a few quarts of engin' oil once in a while. Now, accordin' to all precedents, it's goin' to cost more to run them motors than it would to buy coal to run th' engin', unless a mighty low rate for juice has been made. I would give th' wash fellers th' same advice what I handed out about th' mill. It won't be a mite foolish for 'em to keep th' engin' right to home, for there have been lots of cases where engin's have been started up again after havin' been put on th' shelf while th' company was learnin' wisdom by experience and handin' out dollars to th' central-station fellers."

When th' feller was gettin' ready to get out, I gently put my hand on his shoulder and told him that what looks big in one place was less than commonplace in another, especially in electrical matters, and that although th' two enterprises in Eureka had put in a total of 35½ hp. in motors and while it might be a big thing in that town, it was not a criterion that all steam and gasoline engins were goin' to be put out of business all over th' country. A 20-hp. motor may be some stunt in Eureka, but it would hardly be able to shift th' brushes on th' 3750-kw. shunt-wound, direct-current generator that was built about a year ago.

"Down in th' so called sleepin' city of Philadelphia," says I, "they have a 35,000-kw. turbin' generator and out in Chicago they have a small 25,000-kw. unit. Out on th' Mississippi River there is a plant that will, when it's finished, generate about 300,000 hp., and 150,000 hp. is now in, and out on th' Pacific coast they have an electric transmission line 400 miles long, and one line out that way carries 150,000 volts every day, by heck.

"Just let me give you a little tip," says I. "Electricity may be for futurity, as you said, but it's a mighty big proposition now, and unless both of us turn up our toes pretty dinged soon we are goin' to see some more big stunts pulled off. They won't cause much stir, because things move so fast these days that it takes somethin' more than an ordinary earthquake to make us take notice—we take it as a matter of course and don't give a ding.

"When th' next feller in Eureka puts in a 25- to 30-hp. motor you won't pay much attention to it, for you'll be gettin' used to progress and take it as a thing to be expected. On th' other hand don't be surprised if th' mill and laundry fellers go back to th' steam engin' just as soon as they get th' chance. Goin'? Well, so long."

Most Economical Vacuum for Turbines

By Winslow H. Herschel

SYNOPSIS—Discusses the conditions which influence the degree of vacuum which it is best to carry on a turbine.

It is unfortunate that the word "economy" is used for steam consumption, as a low water rate does not necessarily mean economy at the coal pile. That depends upon the gain in power as compared with the increased cost of obtaining higher pressures, superheat or vacuum. The whole question of cost of power is complicated and depends to such an extent upon local conditions that it is impossible to find any general formula for obtaining power at the lowest cost. Without considering variations in pressure and superheat, factors which mainly depend

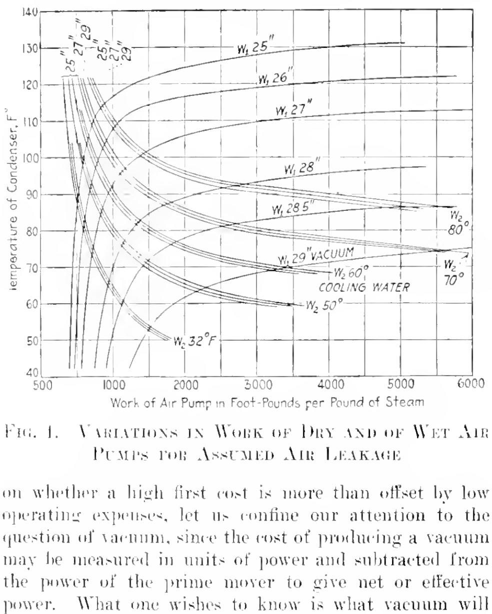


Fig. 1. Variations in Work of Dry and of Wet Air Pumps for Assumed Air Leakage

on whether a high first cost is more than offset by low operating expenses, let us confine our attention to the question of vacuum, since the cost of producing a vacuum may be measured in units of power and subtracted from the power of the prime mover to give net or effective power. What one wishes to know is what vacuum will give the maximum effective power.

In steam engines, as is well known, the large size of cylinders required and the great amount of cylinder condensation prevent high vacuums from being truly economical or from giving a very low water rate, so that a vacuum of about 26 in. is as high as it is advisable to go. With steam turbines, on the other hand, it is possible to have the steam at exhaust nearly at the point of saturation, so that the question of condensation is of minor importance, and it is feasible, at least in large-sized turbines, to design the blading to take care of the highest vacuum which an air pump can produce. The most economical vacuum is therefore not determined by the same considerations as in the case of steam engines.

To simplify the matter it will be assumed that the cooling water is delivered to the condenser by gravity, and neglecting the cost of the cooling water and the higher cost of an installation capable of producing a higher vacuum, we shall consider merely the power required to produce the vacuum by pumping the cooling water, condensed steam and air from the condenser out against the atmospheric pressure. This problem has been investigated by Stodola ("Die Dampfturbinen," Fourth Edition, p. 518) where he has assumed that the ratio of cooling water to condensed steam is equal to 50. It is obvious, however, that this is only an average or special case, since the higher the temperature of the cooling water, the greater will be the amount of it required to produce a given vacuum. In fact, the temperature of the cooling water available is often the deciding factor as to whether a steam turbine or some other form of prime mover shall be adopted, and frequently leads, in warm climates, to the substitution of the Diesel engine.

The presence of air in the condenser is mainly due to leakage through the stuffing-boxes. According to tests of George A. Orrok ("Journal A. S. M. E.," 1912, p. 1625), while the volume of air in city water at 52 deg. F. was over 4 per cent., this had been reduced to less than 1 per cent. in the feed water with a temperature of 187 deg. F. He found that with turbines of from 5000 to 20,000 kw. capacity, the amount of air discharged by the dry-air pump, at atmospheric pressure and temperature, varied from 1 cu.ft. per min., with the units in the best condition, to 15 or 20, when ordinary leakage was present, or to 30 to 50 when the units were in bad condition. These figures are checked by Stodola's statement that we may ordinarily expect the air to amount to 1.5 to 2.5 cu.ft. per min. for each 1000 kw. capacity.

Thomas C. M'Bride (Power, July 14, 1908, p. 74) points out that manufacturers of condensing apparatus for steam engines usually allowed for handling from 4 to 6 volumes of air per 10,000 volumes of exhaust steam, and gives results of tests in which the amount of air varied from 18 to 74 volumes. These figures are based on a 26-in. vacuum and a hotwell temperature of 110 deg. F. He also states that the amount of air to be handled should be as definitely specified as the amount of steam, or else the air-pump manufacturers should not be held responsible for the vacuum obtained.

In a more recent article, Prof. C. L. W. Trinks (*Proceedings* of the Engineers' Society of Western Pennsylvania, June, 1914, p. 497) gives the weight of air normally expected by builders of air pumps as 0.25 to 0.50 per cent. of the weight of steam. This would indicate a growing recognition of the large amount of air usually present in a condenser and its marked effect in reducing the vacuum which would otherwise be obtained.

In the calculations three different amounts of air leakage have been assumed—0.31, 0.62 and 0.93 per cent. of the weight of steam. These amounts correspond respectively, to about 20, 40 and 60 volumes of air per 10,000 volumes of exhaust steam, when reduced to M'Bride's basis of comparison, or to approximately 15, 30 and 45 cu.ft. per min. for every 1000 kw. capacity.

Comparing our assumed values with those of the authorities quoted, we may say that the smallest amount of air could be obtained with stuffing-boxes in the best condition, the second amount under ordinary conditions, while the third value might be reached and exceeded with the stuffing-boxes in poor condition.

The work done by the air pump is found as follows: If p is the pressure in the condenser in pounds per square foot and p_s the steam pressure as given in the steam tables for the temperature of the condenser, then the pressure of the air in the condenser is the difference between these two pressures. Therefore, the weight per cubic foot of the air is $D = \frac{p - p_s}{RT}$, where T is the absolute temperature (that is, 459.6 plus the temperature in degrees F.) of the condenser, and R is the air constant 53.34. Let D be the weight per cubic foot of steam at temperature T. Then, if we have C pounds of air with each pound of steam condensed, the weight of mixture to be pumped for each pound of steam is $C\left(1 + \frac{D_1}{D}\right)$. The theoretical work to compress this weight of mixture, that is, the work required with an ideal air-pump efficiency of 100 per cent., will be

$$W_1 = C\left(1 + \frac{D_1}{D}\right)\frac{k}{k-1}RT\left[\left(\frac{p_b}{p}\right)^{\frac{k-1}{k}} - 1\right]$$

where p_b is the barometric pressure and k is the exponent for the adiabatic compression of the mixture of steam and air which may be taken equal to 1.41. To get the total work of the air pump, $W_1 + W_2$, we must add to W_1 the work required to pump out the cooling water, which is

$$\frac{m\,(p_b - p)}{D_2} = W_2$$

where D_2 is the weight per cubic foot of the water and m is the weight of cooling water per pound of steam condensed. The value of m may be found from the equation

$$m = \frac{H - t_1}{t_1 - t_2}$$

where H is the total heat of the steam, t_2 is the temperature of the cooling water, and t_1 is the temperature of the condenser. The heat H is determined by the vacuum, t_2 may be estimated approximately for any given locality, and t_1 remains to be determined so that the sum of W_1 and W_2 shall be as small as possible. It may make the matter clearer if we imagine two separate pumps—the dry-air pump which does the work of compression, W_1, and the wet-air pump which does the work of pumping, W_2. Then it is evident that with a given temperature of cooling water and a certain amount of air leakage, the vacuum may be increased to the desired amount by increasing the work of either of the two pumps; that is, the vacuum may be improved by decreasing the temperature of the condenser by the use of more cooling water, or by decreasing the pressure by speeding up the dry-air pump. For a given vacuum, W_1 will increase with a rise in the temperature of the condenser, while W_2 will decrease, and at a certain condenser temperature, depending on the vacuum and on the temperature of the cooling water, $W_1 + W_2$ will be a minimum.

In Fig. 1 are shown variations in W_1 and W_2 for an assumed air leakage of 0.62 per cent. of the weight of steam. As W_1 is proportional to the leakage of air, it is easily found for any other amount. Since W_2 varies with the temperature of the cooling water (though W_1 does not), different sets of curves are shown for temperatures of 32, 50, 60, 70 and 80 deg. F., each set consisting of three curves for vacuums of 25, 27 and 29 in. By means of this diagram we have obtained by trial the condenser temperatures which would make the total

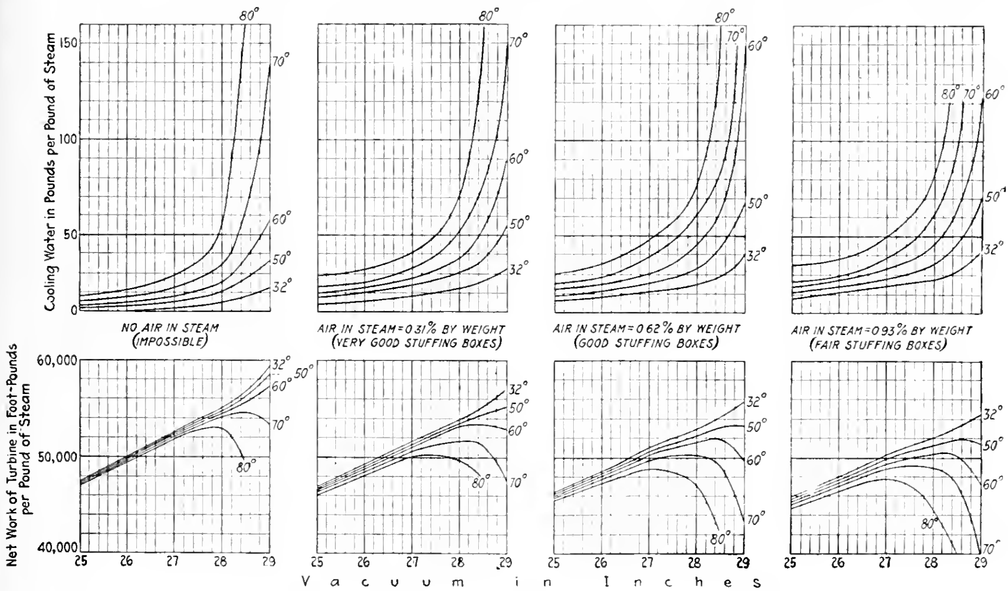


FIG. 2. GRAPHICAL PRESENTATION OF DATA CONTAINED IN TABLES

air-pump work a minimum under various conditions. The results are shown in Table I. With the temperature of condenser known, we are in position to find values of m which are also given in Table I and shown in Fig. 2.

TABLE I

Leakage of Air, in per Cent. of Weight of Steam	Temperature of Cooling Water, Deg. F.	Temperature of Condenser, Deg. F	Vacuum, Inches of Mercury	Total Work of Air Pump, in Ft.-Lb. per Pound of Steam	Value of Ratio, m
0.00	32	77	29	710	21.8
		86	28.5	580	18.2
		98	28	460	14.8
		113	27	370	12.0
		124	26	340	10.6
		132	25	330	9.7
	50	77	29	1180	36.3
		86	28.5	870	27.3
		98	28	630	20.4
		113	27	470	15.5
		124	26	380	13.1
		132	25	360	11.8
	60	77	29	1900	57.8
		86	28.5	1200	37.7
		98	28	820	25.7
		113	27	560	18.3
		124	26	430	15.2
		132	25	390	13.5
	70	77	29	4500	140.0
		86	28.5	1950	61.3
		98	28	1110	34.9
		113	27	700	22.6
		124	26	530	18.0
		132	25	440	15.6
	80	86	28.5	5350	164.0
		98	28	1740	54.3
		113	27	910	29.5
		124	26	660	22.0
		132	25	530	18.7
0.31	32	63	29	2150	32.1
		71	28.5	1560	25.6
		78	28	1280	21.7
		87	27	1000	18.2
		96	26	840	15.6
		105	25	725	13.7
	50	68	29	3300	55.0
		77	28.5	2120	36.7
		83	28	1650	30.2
		92	27	1210	24.7
		100	26	990	19.9
		106	25	720	17.8
	60	71	29	4820	89.8
		79	28.5	2740	52.3
		86	28	2000	37.9
		96	27	1410	27.5
		104	26	1120	22.6
		113	25	930	18.7
0.31	70	76	29	8220	164.0
		83	28.5	4010	75.8
		89	28	2670	52.2
		100	27	1700	32.8
		109	26	1280	25.2
		113	25	1060	23.0
	80	86	28.5	7750	164.0
		94	28	3930	70.0
		104	27	2110	41.0
		111	26	1530	31.8
		114	25	1280	29.0
0.62	32	57	29	3010	40.0
		67	28.5	2260	28.7
		72	28	1860	25.1
		77	27	1440	22.4
		90	26	1200	17.4
		95	25	1020	16.0
	50	65	29	4600	66.5
		73	28.5	2980	43.2
		80	28	2310	33.1
		90	27	1710	25.0
		96	26	1390	21.7
		104	25	1190	18.5
	60	70	29	6820	99.9
		76	28.5	3700	61.9
		84	28	2760	41.4
		93	27	1960	30.1
		99	26	1560	25.6
		106	25	1300	21.7
	70	73	29	11040	328.0
		82	28.5	5440	82.8
		86	28	3570	61.8
		95	27	2300	39.6
		105	26	1770	28.3
		109	25	1450	25.5
	80	86	28.5	10040	165.0
		93	28	5540	75.8
		100	27	4890	49.4
		108	26	2040	35.4
		113	25	1680	30.0
0.93	32	55	29	3840	42.7
		62	28.5	2880	32.8
		68	28	2380	28.0
		73	27	1840	24.5
		77	26	1530	21.5
		93	25	1310	16.5
	50	64	29	5760	70.8
		71	28.5	3730	47.3
		78	28	2920	35.5
		85	27	2150	28.6
		91	26	1760	24.5
		95	25	1480	22.4
	60	68	29	8440	123.8
		75	28.5	4720	66.0
		82	28	3450	45.1
		88	27	2440	35.7
		96	26	1960	27.8
		104	25	1630	22.6
	70	72	29	13250	494.0
		80	28.5	6610	98.8
		86	28	4410	61.8
		95	27	2850	39.6
		103	26	2210	30.1
		108	25	1800	26.2
	80	82	28.5	11330	493.0
		92	28	6960	82.0
		99	27	3520	52.0
		106	26	2560	38.1
		108	25	2070	35.5

In London *Engineering* of Jan. 9, 1914, p. 38, is given a diagram "due to J. M. Newton," showing values of m for various vacuums and initial temperatures of cooling water. The effect of varying amounts of air leakage is, however, not shown as in Fig. 2 herewith. In most cases m would be easier to measure than the average temperature of the mixture in the condenser and could be used as an indication of whether the dry- and wet-air pumps were each doing its proper share of the work.

To find the vacuum which will make the net work a minimum, we must assume the water rate of the turbine and the efficiency of the air pump. By net work is meant the work developed per pound of steam by the turbine, minus the air-pump work per pound of steam needed to produce the vacuum. We have assumed the turbine to be acting under 150 lb. gage pressure, dry steam, without superheat, and have taken air-pump efficiencies of 50, 65 and 80 per cent. Stodola assumed for the air pump an efficiency of 50 per cent. and took for the turbine an admission pressure of 142 lb. with an initial temperature of 572 deg. F., or 218 deg. superheat. Using, as he did, an indicated efficiency of 65 per cent. and a mechanical efficiency of 90, this would be equivalent to assuming that the water rate varied with the vacuum, as shown in Table II, which also gives the water rates herewith employed.

TABLE II

Vacuum in Inches	Water Rate Used by Stodola, Lb. per B.hp. per Hour	Value in Ft.-Lb. of 1 Lb. of Steam	Water Rate Used in Fig. 2, Lb. per B.hp. per Hour	Value in Ft.-Lb. of 1 Lb. of Steam
25	14.0	63,300	18.5	47,900
26	13.5	65,600	17.6	50,300
27	12.8	69,100	16.7	53,200
28	12.1	73,100	15.9	55,700
28.5	11.5	77,100	15.4	57,600
29	11.0	80,500	14.7	60,300

The writer has assumed that the turbine was designed for a vacuum of 27 in. and that, consequently, the efficiency decreases slightly from the maximum of 50.0 per cent. when the vacuum is either higher or lower than the normal. The efficiencies are somewhat lower than the constant value of 58.5 per cent. taken by Stodola and apply more especially to small-sized turbines, while his value would be more suitable for the larger sizes.

Stodola assumed various rates of air leakage up to about 150 cu.ft. per min. for a 1000-kw. turbine, and found that with his assumed efficiency the most economical vacuum was always over 29 inches, increasing with a decrease in the amount of air in the condenser. He used a temperature of cooling water of 50 deg. F. and a value of $m = 50$. Table III shows the results obtained with m having a variable value as in Table I. Where the most economical vacuum is different for two different efficiencies of the air pump, both vacuums are

TABLE III

Leakage of Air in per Cent. of Weight of Steam	Temperature of Cooling Water, Deg. F.	Vacuum, Inches of Mercury	Net work of Turbine in Ft.-Lb. per Pound of Steam, with Air Pump Efficiency in per Cent. Equal to			
			50	65	80	50 (Stodola)
0.00	32	29	58,880	59,210	59,410	79,080
	50	29	57,940	58,480	58,820	78,140
	60	29	56,500	57,380	57,930	76,700
	70	28.5	53,700	54,600	55,160	73,200
	80	28	52,220	53,020	53,520	69,620
0.31	32	29	56,000	56,990	57,610	76,200
	50	29	53,700	55,220	56,170	73,900
	60	29	(50,660)	(52,870)	54,270	(70,860)
	60	28.5	52,120	53,380	(54,170)	71,620
	70	28.5	(49,580)	(51,430)	52,580	69,080
	70	28	50,360	51,590	(52,360)	(67,760)
	80	28	(47,840)	(49,650)	50,790	65,240
	80	27	48,980	50,050	(50,560)	(64,880)
0.62	32	29	54,280	55,670	56,530	74,480
	50	29	(51,100)	53,220	54,550	71,300
	50	28.5	51,640	(53,020)	(53,870)	(71,140)
	60	28.5	50,200	51,910	52,490	69,700
	70	28.5	(46,720)	(49,230)	(50,780)	66,220
	70	28	(48,560)	50,210	51,230	(65,960)
	70	27	48,600	(49,660)	(50,320)	(64,500)
	80	27	47,420	48,750	49,590	63,320
0.93	32	29	52,620	54,390	55,500	72,820
	50	29	(48,780)	(51,450)	53,100	(68,980)
	50	28.5	50,140	51,860	(52,940)	69,640
	60	28.5	(48,160)	(50,330)	51,700	67,660
	60	28	48,800	50,390	(51,380)	(66,200)
	70	28	(46,880)	48,920	50,190	64,280
	70	27	47,500	(48,820)	(49,640)	(63,400)
	80	27	46,160	47,780	48,780	62,060

Note—Where the most economical vacuum is different for two different efficiencies of the air pump, both vacuums are given, the values of the net work, which are not maximum, being inclosed in parentheses.

included in the table, the values of the net work, which are not maximum, being inclosed in parentheses. The same results are shown graphically in Fig. 2 for air-pump efficiency of 65 per cent. For each of the four amounts of air leakage, from zero to 0.93 per cent., there are five curves for the five different temperatures of cooling water assumed. It will be seen that the most economical vacuum is by no means always as high as 29 in.

In the last column of Table III is given the net work of a turbine, assuming the same efficiency for the air pump and the turbine as taken by Stodola, but taking values of m from Table I. A comparison of columns 4 and 7, Table III, shows that a higher turbine efficiency makes but little difference in the most advantageous vacuum, so long as the efficiency of the air pump is the same. In no case, however, would the most advantageous vacuum, for given conditions, be as high as here calculated, because no account has been taken of the cost of bringing cooling water to the condenser, which increases with m and hence with the vacuum.

⁂

Before Applying a Hydrostatic Test to any boiler, gage lines should be located and gages fixed in order to detect any tendency to bulge or become distorted when under pressure and show whether the parts return to their original contour or not. Otherwise, the test will be of little valne or may even do serions damage, leading to failure later. Such tests should be made by skilled and experienced men, never by thoughtless amateurs.

JUST FOR FUN

A Painstaking Job, but in the Wrong Place

A green man taking down some circuits cut the wires and instead of carefully separating the ends on the live side he spliced the two lines together, then soldered and taped the joint. That evening when it was time to turn the current on that line, things were lively for a while. —*Harry D. Everett, Washington, D. C.*

What Is Electricity?

I'm going to slip you one by Ike Hedges. He says: "In the fall of 1913 I dropped off at Bologna, Italy, on my way from Venice to Florence. Consulting my Baedeker, I learned that the famous thing about Bologna was its ancient university, and that three great men in the electrical world had at one time attended this famous institution of learning—Galvani, Volta and Marconi. The conclusion, therefore, is inevitable, that whatever electricity may be, its basic principal is sausage." (Well, it might be "wurst.")—*Terrell Croft*, St. Louis, Mo.

A Lively Time

The second item in the "Just for Fun" column, Mar. 9 issue, reminded me of a similar incident.

The electrical system was being changed from a two- to a three-wire system, and a temporary wooden switchboard was being built above and to one side of the one in use. The carpenter above was nobly trying to balance a long piece of "two by four" that was slowly but surely getting away from him. He yelled for help. His helper below, a large steel square in his hand, realized the need of quick action. He looked around for a place to lay the square, and one of the main switches happened to be the place. The action was quick. No one was seriously hurt, though there was a most confusing mixup of men, fire, noise and the "two by four." The helper, who had vanished as though swallowed by the earth, "showed up" four days later.—*C. H. Dalrymple, New York.*

"A Pound's a Pound the World Around"

I read your "Just for Fun" column with considerable pleasure and was particularly interested in an article in the Feb. 23 issue, page 261, in which the member of the school board made such wise remarks about the flow of steam. It reminded me of a somewhat similar experience while superintendent of a municipal plant in a mining town in Illinois. After a new boiler had been completely installed the Village Board came down to the plant to see it put under pressure. Among the various suggestions for raising the necessary hydrostatic pressure, one was to fill it full, close all valves and build a light fire so that the expansion of the water would give the desired pressure. The idea was all right, only I explained to them that the safety valve was set for only 150 lb. and would blow at that pressure, and would have to have a gag on for the test and that I could pump up the pressure in a much less time. One of the members, the owner and operator of a steam-operated brick yard, said that it ought not to lift at 150 lb. water pressure as 150 lb. steam pressure was equal to 250 lb. water pressure and the valve was set for steam pressure.—*W. P. Martin, Connelton, Ind.*

First Uniflow Plant on Pacific Coast

SYNOPSIS—The requirements demanded generating sets capable of providing elevator and lighting service without flickering lights and also to take care of a large roof sign which is thrown on and off every thirty seconds. The engines and boilers are in a common room; there is no dust, as fuel oil is burned in the boiler furnaces. The uniflow engines on test with less than 150 lb. steam pressure showed an average steam consumption from one-fourth to full load of less than 20 lb. per indicated horsepower-hour.

The power-plant equipment of the New Hotel Rosslyn, Los Angeles, Calif., presents the solution of an engineering problem which will be of interest to engineers. This hotel is 12 stories in height, with basement and sub-basement, and contains, with an annex, 850 rooms. There are four passenger and three service elevators, of the high-speed traction type. It was required to provide generating capacity that would take care of the elevators and lighting load from the same circuit without causing the lights to flicker. Clusters of tungsten lamps against light-colored ceilings and walls were to be used, which would have a tendency to magnify the least flickering of the lights.

In addition to the fluctuating elevator load, provision also had to be made to take care of a large roof sign which was to be thrown entirely off and on at intervals of 30 sec. Besides being able to cope successfully with the fluctuating nature of the load, the plant had to be an economical one, because electricity in Los Angeles is sold on a sliding scale, making it possible for large users to purchase it at a rate of approximately $0.0135 per kw.-hr.

The building was originally laid out with the intention of purchasing current, and therefore the space that could be allotted to the power plant was very small. This difficulty was largely overcome by the fact that oil-burning boilers were installed. The space between the nearest engine and the boilers would hardly permit the slicing of fires if coal were used for fuel.

E. L. Ellingwood, consulting engineer, of Los Angeles, was employed by the architects, Messrs. Parkinson & Bergstrom, to make the plans for the power plant and heating system.

Three "Universal Unaflow" engines were selected, two being of 200-kw. capacity at 200 r.p.m., and the third of 100-kw. capacity at 225 r.p.m. (Fig. 1). Direct-current three-wire generators were selected. The boiler plant consists of three 196-hp. water-tube boilers (Fig. 2), equipped for the burning of fuel-oil. The steam pressure is 150 lb. at the boilers. Saturated steam is employed. The engines on a test at somewhat lower steam pressure than 150 lb. showed an average steam consumption from one-fourth to full load of less than 20 lb. per i.hp.-hr. The plant is a good investment for the owners of the hotel, as the total cost of operation, including interest, depreciation and a charge of $0.50 per sq.ft. per year for floor space, is $0.0116 per kw.-hr.

The total connected load is about 760 kw., of which 260 kw. is motor load; and although this is of a decidedly fluctuating nature, owing to the traction elevators and the intermittent electric sign, no flickering of the lights in any part of the building can be noticed.

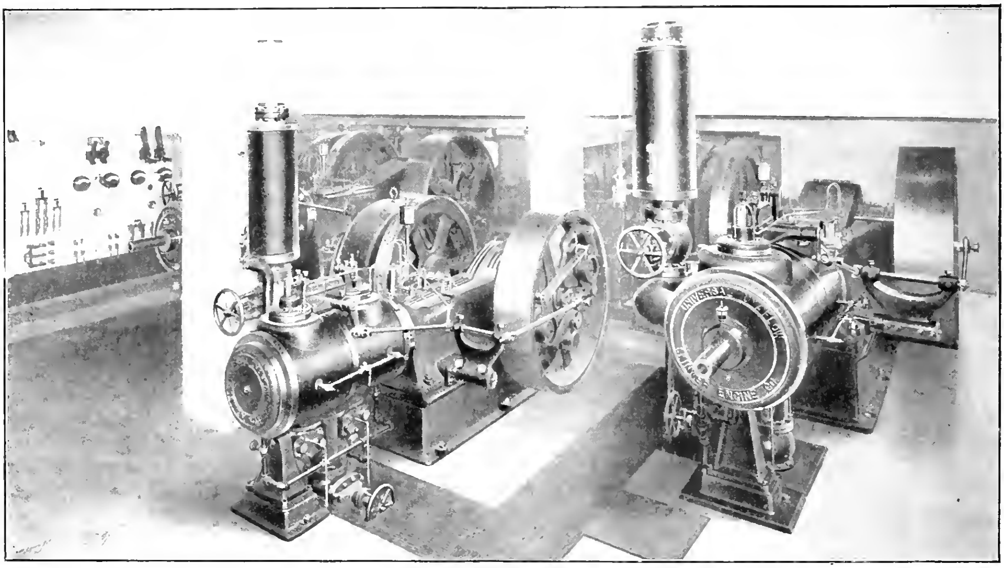


Fig. 1. One 100-Kw. and Two 200-Kw. "Universal Unaflow" Engines Directly Connected to Direct-Current Generators

The engines and boilers will attract the attention of Eastern engineers, owing to the fact that they are placed in one room, which is finished in white. This arrangement is possible and practicable on account of burning fuel-oil under the boilers. The engine and boiler room is well lighted by 200-watt tungsten lamps suspended close to the ceiling. Fig. 3 is a view of the switchboard, which is also shown in part in Figs. 1 and 2.

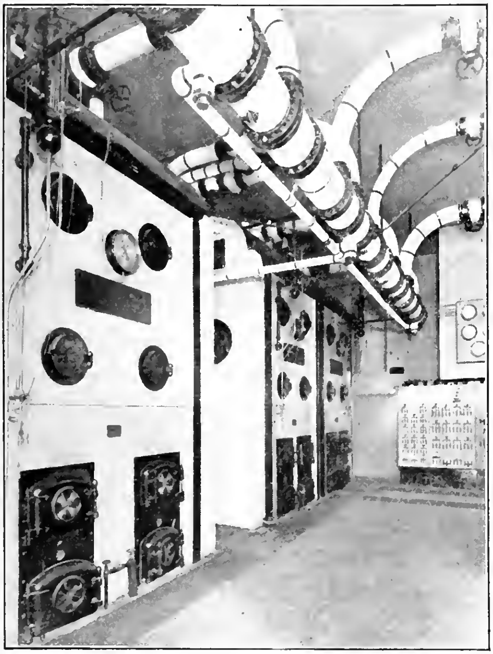


Fig. 2. Three 196-Hp. Water-Tube Boilers; Fuel Oil Is Used in the Furnaces

In addition to the power plant, there is a refrigerating system calculated to provide circulating water in every room at a temperature of 37 deg. F., the test conditions being rigid, as only 8 oz. of water was allowed to be drawn from the faucets in order to arrive at the test temperature of the water. The refrigerating equipment

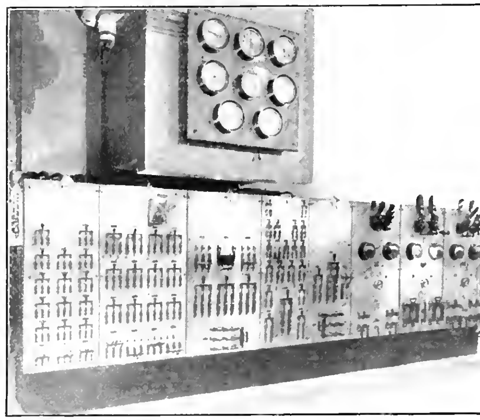


Fig. 3. Switchboard for Generator and Circuit Control

consists of one 18-ton horizontal ammonia compressor, direct-driven by a Corliss engine at 66 r.p.m. The plant manufactures 1200 lb. of ice every 24 hours, and furnishes refrigeration for all cold boxes in the storage department of the hotel, the bar, the cigar and flower shops.

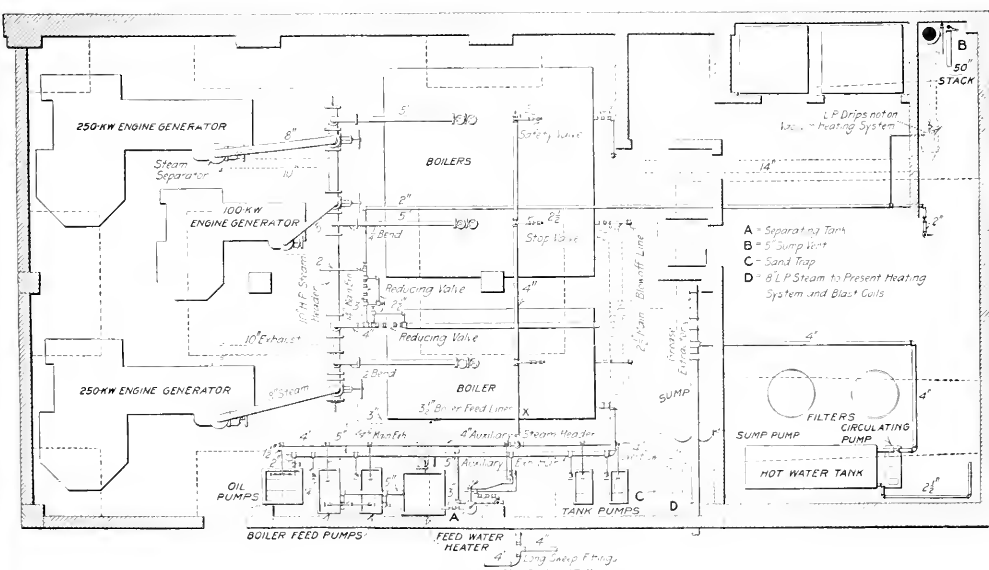


Fig. 4. Plan of Engine and Boiler Room

PRINCIPAL EQUIPMENT OF THE HOTEL ROSSLYN, LOS ANGELES

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
2	Engines	Universal Unaflow	200-kw	Main units	200 r.p.m., 150 lb. steam, saturated	Skinner Engine Co.
1	Engine	Universal Unaflow	100-kw.	Main unit	225 r.p.m., 150 lb. steam, saturated	Skinner Engine Co.
2	Generators	Direct-current	200-kw.	Main units	200 r.p.m., three-wire system	Crocker-Wheeler Co.
1	Generator	Direct-current	100-kw.	Main unit	225 r.p.m., three-wire system	Crocker-Wheeler Co.
3	Boilers	Water-tube	196-hp.	Steam generators.	150 lb. steam, saturated	Badenhausen Boiler Co.
1	Compressor	Ammonia	18-ton.	Refrigeration system	Engine driven, 66 r.p.m., 1200 lb. ice per 24 hr.	Vulcan Iron Works.
1	Engine	Corliss		Driving ammonia compressor	150 lb. steam, 66 r.p.m.	Murray Iron Works
1	Pump	Tank		Water to storage tank		Henry R. Worthington
2	Heaters	Tank		Hot water for house	Thermostatically controlled	Frank L. Patterson
	Dunham heating system for the building, using exhaust steam.					C. A. Dunham Co.
	Ventilating system, exhaust fans.					B. F. Sturtevant Co.

Water for lavatory, laundry and kitchen purposes is heated in a battery of two combination tank heaters thermostatically controlled, the water being circulated throughout the building by centrifugal pumps. The water-supply for the building is from roof storage tanks of 34,000 gal. capacity, automatically filled by a steam-driven tank pump located in the sub-basement.

Steam heat for the building is by means of a system using exhaust steam exclusively.

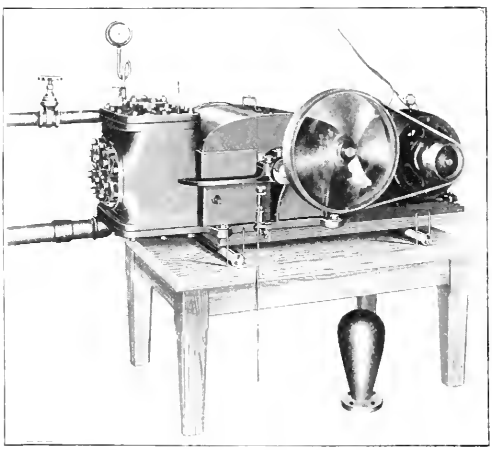
The ventilation in the service department, lobby and dining room and the exhaust ventilation from all the toilets, lavatory and bath systems is provided by fans.

The water for refrigerator, laundry and boiler-room use is treated by the lime and soda process, as Los Angeles city water runs from 22 to 26 deg. German hardness.

The compact nature of this plant, as shown by the plan, Fig. 4, was necessary on account of the limited floor space turned over to the engineer for the installation of the equipment.

Luitwieler Double-Acting Triplex Pump

At the factory of the Luitwieler Pumping Engine Co., Rochester, N. Y., may be seen a double-acting triplex pump operating at speeds from 100 to 300 r.p.m. The



PUMP RUNNING WHILE RESTING ON ROLLS

illustration shows the pump operating upon a pair of polished steel rollers 2 in. diameter, the rollers resting on the top of a table. There is no air chamber on the pump and the gage needle stands still, showing that the water pressure is constant. To show that no vibration exists, a wire nail 5 in. long stands motionless upon the top of the pump; on either side of the rollers other nails of the same size stand on end touching them. If there was any movement of the rollers the nails would topple over, but the pump operates at these high speeds day after day with the same nails standing immovable.

The Luitwieler pump was described on page 53 of the July 8, 1913, issue. All the driving mechanism is inclosed in a bath of oil and needs practically no attention.

Dimensions, Weights and Costs of Steam Turbines*

By A. A. POTTER† AND S. L. SIMMERING‡

Tables 1 and 2 were compiled from data supplied by manufacturers and should prove of value in connection with preliminary estimates. The dimensions, weights and cost data are for condensing units and include the turbines and alternating-current generators.

The values in Table 2 were plotted and the following equations were deduced, giving the cost in dollars (C) of the turbine and generator, in terms of the capacity in kilowatts.

$$\text{Impulse types } C = 5040 + 9.2 \text{ kw. (Dollars)}$$

$$\text{Reaction types } C = 7400 + 8.26 \text{ kw. (Dollars)}$$

TABLE 1—DIMENSIONS AND WEIGHTS OF CONDENSING STEAM TURBINES, INCLUDING GENERATORS

Size Kw	Impulse Type Lgth. ft.	in.	Width ft.	in.	Hght. ft.	in.	Weight Lb.	Reaction Type Lgth. ft.	in.	Width ft.	in.	Hght. ft.	in.	Weight Lb.
300	15	10	5	0	5	4	18,500	16	0	6	0	..	..	24,000
300								20	0	6	0	5	10	37,900
500								18	0	6	0	..	..	30,000
500	16	1	7	3	6	6	34,800	20	9	6	0	5	10	42,600
1000								24	0	6	6	..	..	60,000
1000	16	0	6	10	7	3	45,000	18	4	6	9	6	8	52,250
2000	20	6	9	0	7	9	75,000	25	6	9	4	7	9	105,000
2000								26	0	7	0	..	..	90,000
5000	25	1	10	7	9	8	175,000	34	9	11	5	9	1	236,000
5000								34	0	8	0	..	..	190,000
10000	32	5	12	9	12	0	310,000	45	0	10	0	..	..	320,000

TABLE 2—COST OF CONDENSING STEAM TURBINES AND GENERATORS

Size, Kw	Impulse Type R.p.m.	Cost	Reaction Type R.p.m.	Cost
300	3600	$8,000	3600	$7,650
500	3600	9,600	3600	9,550
1000	3600	14,000	5600	13,750
2000	3600	23,000	3600	22,800
5000	1800	55,000	3600	48,700
10000	1800	95,000	1800	90,000

Duty of a Pump—There are different definitions for what is termed the "duty of a pump," each giving a different estimate of value. The duty is sometimes defined as the weight (lb.) of water raised through a vertical height of 1 ft. for each 100 lb. of coal burned; or, more simply, the theoretical work (ft.-lb.) performed per hundredweight of coal burned under the boiler. It is observed that this definition is faulty, because it combines furnace and boiler efficiencies with that of the pump itself, besides estimating only the theoretical work performed, thus eliminating friction, which is often a most important factor. The true definition of duty in pumping is the actual work performed in a given time (ft.-lb.), per million B.t.u. delivered to the pump in the same time. Or, less frequently, the duty is estimated in foot-pounds of work performed per thousand pounds of dry saturated steam consumed.—"Coal Age."

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‡Instructor in steam and gas engineering, Kansas State Agricultural College.

Editorials

Accepting the Inevitable

Always present in every community are the "kill-joys," who see nothing but ruin ahead if this or that is done. Yet somehow, we always have lived through the administrations that were prophesied to bring the country to disaster and, strangely enough, we are getting better all the time. It seems as though progress has a certain momentum that will carry it on in spite of all obstacles, including the well-meaning people who cannot anticipate success except by time-worn methods.

In this connection a recent utterance of George Otis Smith, director of the United States Geological Survey, in an address at the University of Illinois, is to the point:

The trouble with so many of the business men of the day, and especially with those who come to Washington to oppose new legislation, is their nearsightedness. They cannot see country-wide public opinion and do not appreciate the obvious fact that the financial centers are not also the centers of national thought. The result of this, as I expressed it in conversation last winter with a New York gentleman who was largely interested in water-power development, is that the business interests oppose something at one Congress which two years later they would accept; but the next Congress is already considering a more advanced legislative proposition. We are all more or less progressive, I told him, but the opposition has been just one lap behind.

The bright light of publicity is coming to shine more and more upon the inner workings of all private business which has anything of the public-service character. Only about three years ago, at a conference on water-power policy, I heard the representative of the banking houses interested in the hydro-electric business tell the Secretary of the Interior, with considerable warmth of spirit, that one thing the men who make possible the development of our country by their contribution of capital would not stand for was any legal requirement of inspection of their accounts by the Government. A corporation has its rights, they contended, just the same as a private man in business. Last year in the same room, when the utilization of a large power site owned by the Government was being discussed, I heard those asking for the permit dismiss the question of Federal inspection of their books with the remark, "That need not be discussed, our books will of course be always open to any authorized representative of the Government." The ultimatums pronounced by the ambassadors from Wall Street, State Street and West Adams Street are short-lived in the present atmosphere of popular interest in these business questions.

To go back to our first thought that progress is going to "get there" "nevertheless and notwithstanding," the situation is much like that of a trolley car or automobile trying to cross a busy street. People and traffic will continue to hold up the car by passing in front of it like so many obstructionists until the Law, personified in the traffic "cop," gives the car the sign to come ahead. Then the pedestrians have to look out for themselves and let the car pass. The car loses a little time, and so do the people, but eventually all get on and no harm is done. So it will be with the questions that Congress or State Legislatures are called upon to decide. Ultimately, they will be settled the right way, and the sooner opposition is withdrawn the sooner conditions will adjust themselves to everyone's satisfaction. Right is the good of the majority, and private interests mindful only of their profit will do well to accept the inevitable without expensive delay. It is futile to hinder progress.

Principles versus Details

To most engineers the study of principles is less interesting than apparatus embodying them—details of valves, piping, generators, etc., grip the attention far more readily than what look to be theoretical abstractions. This is only natural, for most people think in concrete terms; the specific appeals to the intellect of the great majority more than does the general; and iron and steel, water and coal, copper wire and insulation, belong so positively to the realm of things seen and handled that many minds never get much beyond these visual conceptions.

Mastery of details is essential to engineering success, but advancement to professional standing calls for recognition of principles. We hear too much about the "man behind the throttle," as though mere manipulation were the index of the engineer's ability. Striking phrases like these are useful in their place, but are largely figures of speech, and their symbolism should not be taken too literally. Without brains to guide the hand on the throttle, to appreciate what goes on on each side of the valve disk, and to anticipate in imagination the results of various steps in plant operation, we should have short shrift from the business world. Power to think in terms of principles—to theorize—is the means to rise out of mediocrity into distinction. Acquiring it means drudgery and plenty of it, but it also means advancement on a solid foundation, with a broad comprehension of the significance of details which mere cleverness in mastering the latter can never supply.

Appreciation of the laws of steam, hydraulics and electricity, knowledge of the strength of materials and comprehension of the chemical and physical principles bearing upon combustion of fuel, the production of steam or producer gas, a broad grasp of the elements of lubrication and of the essentials of heat phenomena, will serve the engineer well in time of need. It goes without saying that to understand the *why* of his work as well as the *how*, these important matters cannot be neglected. Even after a man has gone through a rigorous course in mechanical engineering and spent several years in practice within the plant, it will pay him to occasionally review the fundamentals of his profession. Defects in early training can thus be remedied, and most of us have weak spots in our technical armor.

In these days of distributed information, with interesting bulletins and catalogs coming from all quarters of the land at the price of a postal card, it is easy to form the habit of following *applications* of principles to the exclusion of studying fundamentals themselves. It is amazing how helpful it is to review the elements of steam engineering, for example. Much of the matter can be gone through rapidly, but such a review strengthens the grasp of the reader on the great essentials of his occupation and thereby better fits him to grapple with fresh problems in his own field. Judgment in the application of these principles is developed as the seasoned operating man refreshes his mind again and again with the foundations of his profession; the true significance of detailed practice becomes more apparent, and the ambitious worker thus prepares himself for greater responsibilities and more accurate decisions.

For Industrial Betterment

General industrial activity makes for our prosperity as a nation. If the shops and mills are inactive, this depression affects all seriously, including the operating engineer, whose function it is to keep the power wheels in motion.

As the time approaches for the convening of the two largest organizations of operating engineers in America, it is to be hoped that, with their avowed objects for general good and their tremendous possibilities for advancement in knowledge and prosperity, they will give some heed to the upset and unrest of business conditions and find means to coöperate with the commercial interests in seeking a remedy.

While the war has had its influence, helping some business although hurting most, it would not account for so much idleness when the crops are big and their prices high, when our financial condition is strong, and when labor and capital were never so willing to coöperate. Conservatism, or in other words, lack of confidence seems to be the trouble. It is a time when the cautious are very slow about taking even the slightest risks.

One contributing cause of this uncertainty and fear is that honest business interests are in doubt as to just what they can do lawfully in the face of so much new and untried legislation. They do not know how to conduct their affairs in accordance with laws that are apparently interpreted one way today and another tomorrow, consequently, some have ceased to do business; their plants are closed and their employees idle. A wild "tooting on the horn of plenty" is merely noise, not a remedy, nor is the "popular" legislation of those politicians who are actuated by narrow and sordid self-interest. Our industrial prosperity furnishes the sinews of our citizenship, and our membership in the engineering organizations gives us ample authority to work in every legitimate way for those interests. No one influence has been so powerful as that of the engineers in placing wise boiler laws on the statute books, in safeguarding lives and property against criminal operation of power plants, and in framing the license laws governing our fellows. Is it not time, then, that we voice our protest against unwise legislation, investigation and control wherever and whenever it affects us? Our Government is a government of the people; we have a part in it. It is sovereign in its power to so adjust and fix conditions that we, the people, may enjoy the honest activity in our vocations, which is our right.

We need a much wider publicity for each proposed legislative measure, whether it affects our field directly or only indirectly. Therefore, we believe that every organization whose purpose it is to uplift and promote the interests of its members should have timely knowledge of proposed laws, and when affected by them should have the chance to express its approval or disapproval.

Cutting "Lumber" out of Reports

Ability to write a clear-cut, straightforward report unencumbered with superfluous material is worth cultivating. Many an operating engineer would dread the task of preparing a report, for instance, on the desirability of replacing a vertical cross-compound engine with a turbine. Usually, it is not so much the engineering problem as the literary end of the work that looks burdensome. Sound figuring is demanded first of all, but if the correct conclusion is reached there should be little further anxiety.

The form of report desired will depend on the employer, but most busy men want a terse, clear statement of conclusions, to which they can turn at once. While it is proper to include it, the reasoning upon which the recommendation is based is secondary. It is very easy to encumber a report with useless description and discussion. Such matter has appropriately been called "lumber" by an engineer experienced in scanning written matter, and good judgment in eliminating it is profitable.

In the case mentioned, a well-considered report might follow a statement of the problem in hand, with the conclusion that it will pay to make the change and that the annual saving would be about a certain sum. The rest of the report may then be an appendix in support of the contention.

The argumentative part of the report might include a statement of the capacity and service of the equipment to be displaced and the present operating costs and fixed charges, taking care to mention all assumed factors, like the percentage of interest, insurance and depreciation allowed. Test data on which existing cost figures are based may be summarized, and the limitations of the equipment in point of space, in meeting a growing load, etc., discussed. Then should follow an estimate of the cost of substituting a unit of increased capacity, with the fixed charges and estimated operating cost, with the statement of authority for steam consumptions assumed, guarantees offered, etc., and a final tabulation of yearly cost of a stated service, with a checking of the total against the present total if desired, or a comparison of unit expenses at the busbar. Modifications in auxiliary plant should also be covered in their proper places.

In presenting such information literary style will largely take care of itself if the report is logical and intelligible at all points. If it lacks clearness, if it cannot be checked by another competent engineer without consulting the writer, if it includes long and rambling accounts of possible equipment combinations without predicting definite results, and if it fails to concentrate similar information effectively, the force of the engineer's recommendations may be greatly weakened.

It is the technical judgment of the engineer that the employer values, and the selections of factors, the arithmetical processes and methods adopted concern him less. To an extent, the less language a report contains, the more helpful it will be to the employer's decision.

In January, 1909, a half dozen years ago, President Roosevelt wrote:

> The people of the country are threatened by a monopoly far more powerful, because in far closer touch with their domestic and industrial life, than anything known in our experience. A single generation will see the exhaustion of our natural resources of oil and gas and such a rise in the price of coal as will make the price of electrically transmitted water power a controlling factor in transportation, in manufacturing and in household lighting and heating.

And it still threatens; witness the defeat by its proponents of administrative water-power legislation in the late Congress.

Correspondence

Theoretical Efficiency of Heat Engines

The article by Mr. Heck in the issue of Apr. 20, concerning "Theoretical Efficiency of Heat Engines," contains a reference to an earlier statement by myself in POWER of June 9, 1914. In general, the detailed analysis of the problem by Mr. Heck is entitled to unqualified approval, were it not for the risk that some of the inferences might contaminate the future bibliography on the efficiency of heat engines because of an incomplete quotation of my remarks. The omission of the closing sentence of the paragraph to which reference is made is herewith supplied: "This (53.3%) cannot be approached on account of practical limitations." This would seem to be sufficient reassurance that I am not disposed to attach any value to the perfect gas formula as an indication of the attainable performance of heat engines.

In stating the "perfect gas" formula as a limit, I am not only safe, but also following the practice of authorities in thermodynamics sufficiently to remove the second law, for which the formula is simply an algebraic expression, from the realm of discussion. There may be other and lower limits for particular operations, but they do not serve as a means of disproving the validity of the Carnot cycle as one of limiting high efficiency. Nor do they establish "ideal steam cycles," as there are alternatives to the Rankine cycle which surpass it in efficiency.

There is a process, as indicated by Boulvin in 1897 and reproduced in the translation by Bryan Donkin of "The Entropy Diagram and Its Applications," which produces a working cycle for any fluid, including steam, attended

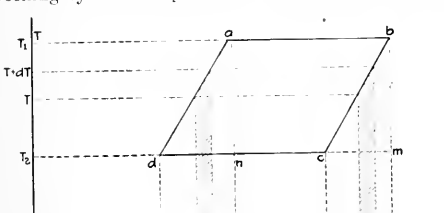


FIG. 1

by a higher efficiency than that of the Rankine cycle. In fact, carried to the limit it would have the same efficiency as the Carnot cycle, theoretically. In order to avoid a further misinterpretation I will now insist that this cycle, like that of the Carnot, cannot be completely realized on account of practical limitations. Nevertheless, an incomplete process can be devised and has actually been applied with noticeable improvements over the Rankine cycle.

Referring to the entropy diagram Fig. 1 (Fig. 7, Boulvin-Donkin) as reproduced without reference to a scale, *ab* and *cd* are isothermal lines, *bc* is an arbitrary path of the working fluid, *ad* reproduces and is exactly parallel to *bc*. The heat converted into work is proportional to the area *abcd*, or its equivalent as a rectangle *abmn*. The heat rejected in the cycle consists of two parts represented by the areas *cdd'c'* and *bcc'b'*. The latter is exactly equal to the heat required to carry out the process *da*. If, in the course of rejection of heat along *bc* and the drop of temperature from $T + dT$ to T a means is provided for storage of this heat and the maintenance of such tem-

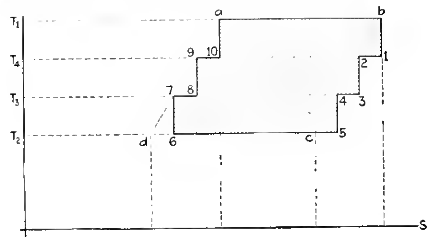


FIG. 2

peratures, it may with adequate equipment be applied to the heating of the fluid at a certain part of the path *da* without the intervention of a source of heat. The heat stored is represented by *bcc'b'* and is returned to the fluid as the area *d'daa'*. The efficiency of the cycle is the ratio

$$E = \frac{abcd}{d'dabcc'} \quad \frac{abmn}{a'abb'}$$

Since an infinite number of heat reservoirs cannot be applied, the theoretical limits of the cycle cannot be realized. But a modified adaptation of a limited number of regenerators or heat reservoirs, each operating in a particular temperature range, can be applied, with the result that the limit of thermal efficiency may be considerably higher than that of the simple Rankine cycle. The latter is not, therefore, an "ideal steam cycle."

Referring to Fig. 2 (Fig. 8, Boulvin-Donkin); replace the continuous line *bc* by the broken line *b 1 2 3 4 5 c* and the line *da* by a similar broken line *d 6 7 8 9 10 a* and we have a cycle having the same efficiency as the Carnot and which may be designated as a system for "regenerative" feed heating. The essential features of this cycle consist of abstraction of heat from the steam during its transit through a multiple-expansion engine and a successive higher heating of the feed water in a number of closed heaters, transferring their heat at different temperatures between T_1 and T_2. For example, the heat absorbed during the operation *1 2 4 3* and between the temperatures T_3 and T_4 is transferred to the feed water after it has been heated to the temperature T_3 and through the part *7 8 9 10* of the cycle. A perfect storage and restorage of heat in this manner is impossible, but a move in that direction, with highly gratifying results thermodynamically, has been made in the case of the multiple-expansion pumping engine for the Wildwood station of the City of Pittsburgh and devised by B. V. Nordberg.

A simple addition of but two elements of this regenerative feed-heating process is capable of such improvement of the Rankine cycle and of the illustrative example proposed by Mr. Heck that his figure of 0.335 for thermodynamic efficiency is too low and is not therefore an "ideal steam cycle." Moreover, the limitation of saturated-steam temperatures to 380 deg. F. is one which engineers need not hesitate to transgress, as pressures of 700 lb. per sq.in. and more on certain types of small boilers have been applied without calamity. The rapid improvements in the construction of steam turbines reveal that their designers are possessed of sufficient courage to venture on even to the utilization of a modified regenerative feed heating to further improve the cycle of operations, when, if ever, we may hope for a near approach to the realization of an efficiency indicated by the "perfect gas formula."

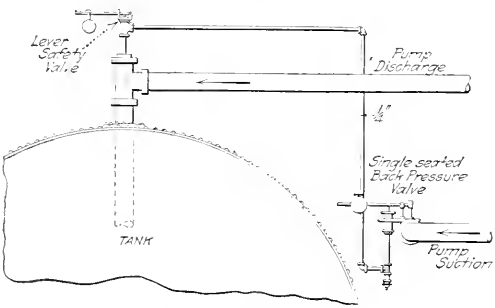
F. G. Gasche.

South Chicago, Ill.

Pump Regulator

The owner of a greenhouse wished to install a gas-engine-driven pump for watering. To provide for future demands for more water, and to avoid excessive pressure if the demand should decrease while the pump was being operated, it was necessary to provide for controlling the flow by means of the variation in pressure.

An ordinary single-seated back-pressure valve with outside dashpot was purchased and remodeled, the dashpot being placed on the opposite side so that pressure under the piston tended to close the valve. A common lever safety valve was connected to the discharge pipe near the tank, with its discharge leading through a 1/4-in. pipe to the bottom of the dashpot. A drip-cock was placed in this line for relieving the pressure, but it was not necessary.



Piping of Regulator

In operation, when the pressure exceeds that for which the safety valve is set, the valve opens and admits water under pressure to the dashpot. This raises the lever and weight and closes the valve. The pump then runs idle until the pressure in the tank falls and the safety valve closes. The slight leak around the stem of the safety valve relieves the pressure and the suction valve opens, due to the weight.

The pipe leading to the safety valve is extended nearly to the bottom of the tank to avoid loss of air, which would leak much faster than water if the seat of the valve should become worn.

To prevent the pump from becoming air-bound when running idle, it was necessary to drill and tap the water passages at the ends of the cylinder and connect check valves. The discharge from these was run through a globe valve to the hopper of the engine, and the overflow led to the sewer. This gives the engine cooling water in sufficient quantities when the pump is working, and the water in the hopper is sufficient for cooling when the pump is running idle.

The device will operate to open or close the suction with a variation of 5 to 6 lb.

A. H. Bullard.

Syracuse, N. Y.

Preventing Water Hammer in Blowoff Pipes

Regarding the suggestion of a safety valve on the blowoff line by Mr. Fenwick in the issue of May 11, page 650, and the editor's comment that the boiler might be drained of water should the safety valve on the boiler become sluggish, there is little likelihood of the valve opening at all after it has been in use a short time. Such has been my personal experience with safety valves on hot-water outlets, unless moved off their seat every day.

A safety valve will work on cold water, air and steam, but if hot water containing even a small quantity of lime or other scale-forming material is allowed to pass through it, the valve will become so attached to the seat that it may require a sharp blow to loosen it after the spring is removed. The surest way of preventing water hammer is to use two valves—one a slow-operating screw stem and the other a quick-operating one if desired—and always open the quick-acting and close the slow-acting valve first.

James E. Noble.

Toronto, Ont., Canada.

Stopping Leak in Heater Tube

By exploring with a lighted candle over the tops of the tubes in a vertical-tube heater under slight pressure, it was found that one was leaking. The candle would be instantly extinguished when held over the leaking tube, but not when held over the others. By sliding a wad of waste into the tube on a wire it was determined that the leak was about half-way down. The heater could not be spared long enough to put in a new tube. The question was how to stop the leak. To plug the tube in the usual way the heater would have to be taken down to get at both ends.

The first attempt consisted in driving into the tube each side of the leak a wood plug long enough to reach the heater heads at both ends. This did little good.

Next, a quantity of Smooth-On cement was put on top of the plug below the leak, another plug driven in, with its top above the leak, more Smooth-On cement added, with still another plug on top extending to the upper head. Had sufficient time been allowed for the cement to harden, this plan would probably have been successful, but the tube got to leaking again after a time.

The trouble was finally stopped as follows: A plug long enough to reach to the bottom head of the heater was driven below the leak and a quantity of molten babbitt was poured in and tamped tight with an iron bar. Then another plug long enough to reach from the babbitt already in to a point above the leak was driven in, and more babbitt was poured and tamped. A plug reaching to the top head was then put in, and the leak was effectually stopped.

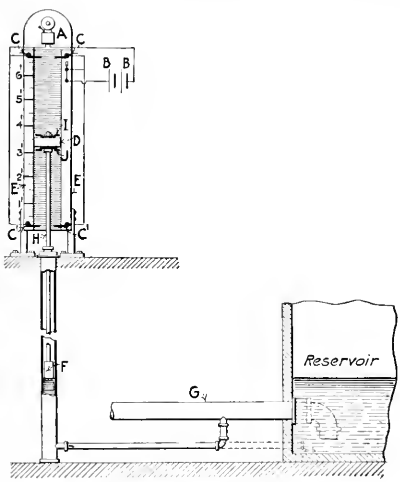
G. E. Miles.

Denver, Colo.

Reservoir Indicating Gage

Originally, the only way of telling the amount of water in our 17,500-gal. reservoir was by going out and looking down into it. In summer it was not so bad, but when the thermometer registered 40 deg. below zero it was different.

I constructed a gage to indicate the water level, which works to perfection. On a 1x6-in. board, the length of which corresponded to the depth of the reservoir, I fastened two pieces of 2-in. maple flooring *E* with their grooves facing each other. A block *D*, to slide freely in the grooves, is fastened to a light rod *H*, and on the end of this rod is a float *F*. A 3-in. pipe is used for the float to work in, and this extends down to the level of the bottom of the reservoir. A ½-in. pipe connects the 3-in. pipe to the suction pipe *G* (or to the bottom of the reservoir itself) and maintains the same water level in the 3-in. pipe as that in the reservoir. To the block *D* are fastened springs *I* and *J*, and to the top and bottom of the board



Indicator and Alarm

are fastened contacts *C* and *C'*. At the top a bell is placed connected to batteries *B*. The gage is graduated in feet and inches and is so marked that the reading corresponds with the height of water in the reservoir.

When the reservoir is full the spring *I* on the block makes contact with *C* at the top, completing the circuit and ringing the bell, and at the bottom a similar contact is made when the water is low. The wiring is concealed behind the gage board, and a switch can be used to cut out the bell.

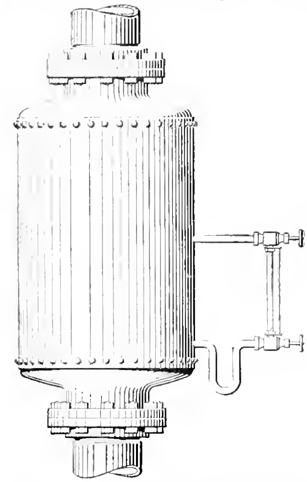
The gage is located in the most convenient place and wired so that the bell may be where the operators are most likely to hear it.

Thomas K. Lee.

Benson, Minn.

To Prevent Gage-Glasses Breaking

Anyone troubled with separator glasses breaking should make a drop or trap in the bottom connection so as to form a water seal. This will stop the flow of steam



Water Seal in Gage Connection

in the glass. The drop needs to be only from 3 to 6 in. The illustration shows the application of the idea.

Fred W. Schneider.

Clay Center, Ohio.

Steam Pressures and Piston Speed

The editorial on page 548 of the Apr. 20 issue very properly called the attention of the operating engineer to the increased hazard in engine operation today, as compared with twenty years ago, due to the increase in the steam pressures used. I had thought to criticize this editorial, because it did not take account of the fact that during the time steam pressures have been mounting higher and higher the demand for closer regulation for electric-light engines has increased, and in order to meet this demand for closer governing the weight of the flywheel has steadily increased.

The increased weight of flywheels has acted, of course, to retard the speeding up of the engine when the governor lost control, and this, in some measure, has acted to counteract the effect of the higher steam pressure tending to hasten the approach of the bursting speed in case of accident. I hesitated about sending such a criticism in, because it requires considerable temerity to take issue with an editor and I was not so sure that I was altogether right, not holding a first-class engineer's license; but since I have seen the remarks on this same editorial by Mr. Williams on page 585 of the Apr. 27 issue, I am willing to take a chance.

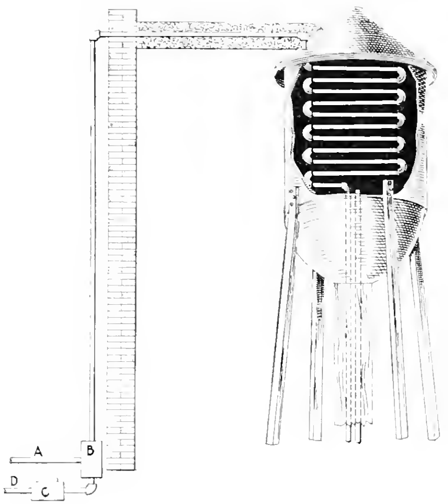
How a change in engine design during the last 25 years so that a working piston speed of 600 ft. per min. has been made 900 ft. per min.—or if made 9000 ft. per min.—could have such effect on the safety of flywheel operation as pointed out in Mr. Williams' article, is more than I can understand. Calling attention to the high piston speed of the modern engine as a factor contributing to flywheel accidents seems about on a par with figuring the explosive energy in a boiler from the number of pounds of coal burned per square foot of grate surface. Will not Mr. Williams enlighten us further on how high piston speed affects the safety of the flywheel?

A. K. JONES.

Melrose, Mass.

Steam Coil in Water Tank

The illustration shows a large water-supply tank. It is exposed, that is, it is erected outside and elevated 60 ft. from the ground; the water is pumped by motor or windmill from a river some distance away. The pipes to and from the tank are run underground in a waterproof



STEAM CONNECTIONS TO THE WATER TANK

box. The pipe *A* carries the exhaust from three duplex steam pumps, one of which is always working and sometimes all three are in service. A separator *B* that removes water and oil from the steam is provided, and another, *C*, which removes the oil from the condensate, so the clean water flows along pipe *D* and discharges into the hotwell; the oil is discharged into a filter. The exhaust riser runs to the tank, where it enters a coil surrounded by the tank water.

Where the pipe passes from the building to the tank it is covered for protection from frost and cold. The steam in the coil keeps the water in the tank from freezing. The water is used for domestic service as well as for the power plant, therefore the exhaust steam could not be discharged directly into it. The water in the pipes or tank has not frozen, although the outside temperature has been as low as 30 deg. F. below zero. A relief valve was attached to the exhaust pipe near the pumps to provide for any possibility of a stoppage in the coil or elsewhere.

JAMES E. NOBLE.

Toronto, Ont.

Ballade of the Stokers

The following clipping from the *Cleveland Plain Dealer*, I believe, expresses the true inward feeling of the stoker in a moment of resentment. You may care to use it.

Our muscles ache from stretch and strain,
 Our eyes are sore with salty sweat;
Our blistered skins are gnawed with pain,
 Our souls, the Devil claims for debt.
 Before us there a gage is set—
The only oriflamme we know!
 Above, they fight the foe we've met—
Who gives a damn for us below?

The great guns boom across the main,
 The Steam Boss comes with curse and threat.
We stuff the hot, red maws in vain
 Another pound of steam to get!
 With senses taut, we toil and fret
And wonder how our fortunes go
 Above, we know they battle yet—
Who gives a damn for us below?

A crash—a roar—and cries profane!
 We slip, we sprawl—our floors are wet!
The bulkheads close, and we—remain!
 The Steam Boss lights a cigarette.
 The hot steam scalds, the waves abet—
We choke—we die—we have no show
 To save the rest! But where's regret?
Who gives a damn for us below?

Prince! And you of the epaulet!
 The world on you will praise bestow,
From Admiral to young Cadet.
 (Who gives a damn for us below?).—Planchette.

WILLIAM D. TAYLOR.

Lorain, Ohio.

Boiler Inspections

In a recent issue it is stated that boiler inspectors do not always report defects, to which statement I agree. We have state inspection here, but it seems as if the main thing is to get the inspection fee. I have been inspecting boilers for some time for various companies and have followed both the state and insurance-company inspection in various plants.

In one plant in New Mexico I was sent to inspect three horizontal-tubular boilers carrying 150 lb. pressure that had been inspected about fifteen days before. The following defects were found: A handwheel was gone on a water-gage cock; three wheels missing on the gage-glass cocks; brickwork on all the boilers in bad shape; a 6-in. globe valve had a hole in the body, over which a piece of packing was clamped to stop the leak; the pressure gages had not been tested for three years; some flues were leaking on all of the boilers at the back head, and two of the boilers had small bags on the fire sheet; in one boiler two braces were broken and they all needed scaling. I recommended that the plant be closed until repairs were made, and the superintendent nearly had a fit.

Another plant contained water-tube boilers that had been giving trouble from pitting tubes. The engineer claimed to have been an inspector and resented my making an inspection, but as I was boiler foreman I made one at the next washout. The tubes were clean owing to using a cleaner. When the manhole was removed on the steam drum, the steam line was found leaking so badly past the valve that the line had to be cut and a blind gasket put in to keep the steam out.

The drum was badly scaled, seven riser tubes were plugged and the rest were dirty. The risers were cleaned and a new set of tubes recommended, also that all leaks in the steam line and valves be repaired before the boiler was returned to service.

It is time that the United States Government controlled the inspection of all boilers or enacted some law that will make it a criminal offense to report a boiler in good condition unless it is so.

L. B. MOORELAND.

Denver, Colo.

Charging Small Storage Batteries

In charging a small storage battery the common method is to use a bank of lamps for regulating the current, as shown in Fig. 1. By this means the current passing through the battery is roughly determined by the number and size of lamps used. The simplest way to determine the correct battery connection is to connect the wires first one way, and then the other, and note which way the lamps burn the dimmest; the dimmest is the correct way. Another simple method is to put the ends of the wires into a cup of water containing a little salt, acid or sal ammoniac; the wire around which the most bubbles are seen is the negative and should be connected to the negative side of the battery.

The foregoing method is very wasteful of electrical energy. Suppose a three-cell battery is to be charged from a 110-volt circuit; the battery will take only a little over six volts and the difference must be taken up by the lamps. Therefore, less than 7 per cent. of the energy expended is actually used in charging the battery.

To avoid this loss the writer devised the method shown in Fig. 2, where L and L' represent the wires leading

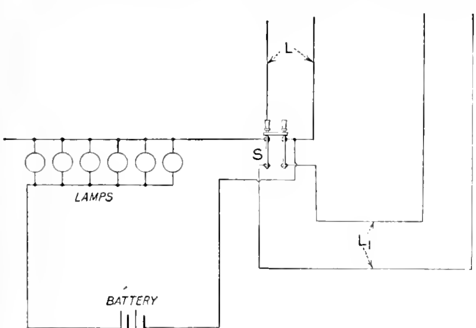


FIG. 1. USUAL METHOD OF CHARGING BATTERY

from the exciter to the main field of an alternator and S is the usual double-pole switch on the exciter circuit of the switchboard. One of these wires is disconnected from the switch S and is connected to one side (2) of a two-point switch, the common point (1) of which is connected to switch S at P. From terminal 2 on the two-point switch a wire leads to one side of the battery and the other side is connected to the remaining point (3) of the switch through an ammeter. A rheostat is connected as shown so that the current flowing through the battery can be regulated. The meter must be connected so as to measure only the current flowing through the battery.

When the two-point switch is connected from point 1 to point 2 the battery is out of circuit and should have one of its wires disconnected to prevent it from discharging through the rheostat. The battery should never be connected in circuit when the exciter is not running, for then it will either discharge through the rheostat or through the exciter, depending on which way the two-point switch is thrown.

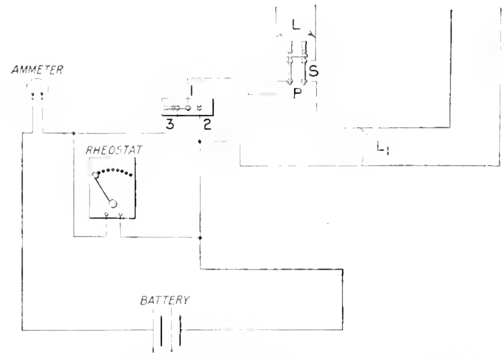


FIG. 2. CHARGING BATTERY IN SERIES WITH GENERATOR FIELD

When not charging, the two-point switch is turned to connect from 1 to 2. To put the battery in circuit, first connect the wires to it and then turn the switch to connect from 1 to 3. If the connections are right the voltage on the machine being excited will fall slightly as the voltage of the battery is deducted from that of the exciter, but if the connections are wrong the voltage of the machine will be raised slightly, as the voltage of the battery will be added to that of the exciter. This is the only test for polarity required. The battery should always be disconnected before shutting down the machine charging it, as otherwise its current will be discharged through the exciter armature and the polarity of the machine may be reversed.

When charging batteries by this method the only energy wasted is the little taken by the rheostat. This will depend on the current required for charging as compared with that passing through the exciter circuit. If the exciter circuit does not carry as much as is called for to charge the battery, the latter will have to be left in circuit longer; that is, it will have to be charged at a lower rate.

G. E. MILES.

Denver, Colo.

Electrically Controlled Damper Regulator

In Mr. Carples' comments on my letter that appeared under the above heading in POWER, Apr. 13, page 517, he says he believes it would be difficult to determine the quantity of air required to burn a certain kind and quality of coal per square foot of grate per hour. He further says I do not explain how this is determined. It is quite easy to determine, when one is getting the best possible flue-gas analysis daily, and the coal runs uniform, as it does.

Mr. Carples is quite right in his contention that the quantity of air required changes with the quality and kind of coal and must be redetermined when these factors change. It is well known that the average CO_2 can be kept at a higher percentage under close draft regulation than when allowed a wide fluctuation, and that under close regulation the efficiency of a boiler will be high.

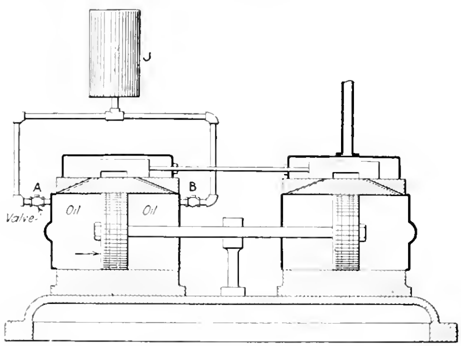
There is no balanced-draft system that I ever heard of that operates without blowers. What my letter makes clear is that we accomplish results nearly equal to those obtained by balanced-draft systems and without the use of blowers or the cost of power to operate them. I hope this is clear to Mr. Carples.

HENRY W. GEARE.

New York City.

Supply for Oil-Cushion Cylinder

On large hoisting engines and others which are reversed frequently the links are shifted by an independent steam-cylinder equipment. In order to avoid too quick and destructive motion of the piston, another cylinder filled with oil is fitted with a piston and D-valve and connected, to oppose the steam piston's motion by acting



CUSHIONING DEVICE FOR REVERSING ENGINE

on a cushion of oil. The illustration shows the general arrangement.

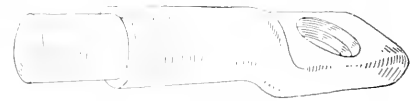
If the oil does not entirely fill the cylinder there is sure to be a jerky motion at the beginning of the stroke somewhat similar to that of a direct-acting pump which is getting air with the water it is pumping. To make sure that the cylinder was filled at all times, I connected a large oil cup *J* to the oil-cushion cylinder by means of small pipe and check valves *A* and *B*, as shown. The action is as follows: When the piston moves in the direction of the arrow, check valve *A* opens, if there is a partial vacuum created, and admits a little oil. At the same time check *B* is closed, so that there is no escape of oil through it. In the other direction the action is reversed, and the oil cylinder is kept full at all times.

G. D. DEARBORN.

New York City

Home-Made Lugs

While making some changes on a direct-current switchboard some time ago, we ran out of lugs, or terminals, and as it would take two days to get them from the nearest supply house, we decided to make them out of half-inch brass pipe annealed by heating to a dull red and ducking in water. We then sawed off several pieces



TERMINAL LUG MADE OF PIPE

about 2½ in. long and drove a piece of ⅝-in. round iron in one end about 1 in. The other end was then put in a big vise about 1¼ in. and flattened down. The iron was then removed and the hole drilled in the flat part, which was then finished up with a file. The lugs proved to be just as strong as the cast ones and, being of brass, were also good conductors. This saved us two days' delay.

J. GERBER.

Dansville, N. Y.

Paper-Mill Power Plants

I have been a reader of POWER for a long time, but do not remember reading any articles about the paper mills. I am now in charge of a plant consisting of 3300 hp. in steam and 1400 kw. generated by water power, furnishing power for making sulphite fiber and paper. Perhaps I am over-zealous in my line of business, but I should like to hear from others working along the same lines, and perhaps we might compare notes and help one another Only one who has worked at it can know the varied experiences encountered in the pulp- and paper-mill work

Steam is used for everything, from thawing frozen pulp to blowing out screen plates, and when things are going along fine, suddenly a 6-in. pipe line is opened into a digester, or two or three steam jets into the beaters, which will keep a man guessing how his coal report will look in the morning.

Let's make ourselves heard.

W. H. HOLMES.

Lincoln, N. H.

Examination Questions

I am sending a list of questions (from memory) which were recently asked in an examination for the position of third-class engineer, hoping they may help others.

1. What causes scale, and how is it prevented?
2. What is a water column, and is it always dependable?
3. What is a fusible plug, and what is it used for?
4. Describe a heating system, and show how condensation is returned to the boiler.
5. Name several causes for an engine pounding and the remedy for each.
6. How is an engine governed? Describe a governor.
7. Describe a feed-water heater, and give two reasons why water should be heated before entering a boiler.
8. What parts of an elevator should be inspected daily?
9. What care should be used in starting a new boiler?
10. (a) Sketch a round pipe strap. What is the vent for? (b) How is a 4-in. soil pipe calked?

RAYMOND J. CAREY.

Fitchburg, Mass.

Inquiries of General Interest

Short-Stroke of Pump—What will cause a duplex pump to reverse before completing the stroke?

C. W. O.

The pump will short-stroke if the lost motion of the steam valve is not enough to delay reversing of the steam valve until the piston has completed its stroke.

Changing from Noncondensing to Condensing—What difference should be made in the setting of the valves of a compound engine to run condensing in place of noncondensing?

M. D.

For running condensing the principal change required in the valve setting would be to secure earlier closing of the exhaust valves of the low-pressure cylinder, so as to obtain the same cushioning effect from compression of exhaust steam of lower pressure.

Flash and Burning Points of Oils—What is the difference between the flash point and the burning point of an oil?

J. R.

The flash point is the lowest temperature at which the oil discharges vapors that ignite with a flash when a lighted taper or match is passed at intervals of a few seconds over the surface of the oil, while the burning point is the temperature which the oil must attain for the vapors to burn continuously over the whole surface.

Advantage of Narrower Belt—Where the narrower belt is sufficient for transmission of the power, what saving of power would be obtained by substituting a 3-in. single leather belt in place of a 4-in. single leather belt for transmission of power from an electric motor?

P. C.

For the same total belt tension there would be no saving of power except that lost in bending the wider belt around the pulleys. With belts in good condition, the power thus lost is so small that the saving from use of the narrower belt would be inappreciable.

Why Smaller Discharge Pipe Worked Better—For pumping water over a hill a pump with a 4-in. discharge pipe would not do the work, but upon replacing the pipe with one 2½ in. diameter, a satisfactory amount of water was delivered. Why should delivery be better by use of the smaller discharge pipe?

E. A. W.

It is probable that at a time when the larger pipe was in use a greater rate of discharge was permitted from the lower end than was being supplied by the pump, and that siphonage caused the discharge line to become airbound at the crest of the hill.

Kinking of Boiler Flue—What would cause one flue of a return-tubular boiler to become warped, or kinked out of line, more than others in the same horizontal row?

F. K.

If the flue was under stresses of cold bends, such as it might have received from rough handling or from straightening the flue before it was set in the boiler, the stresses present would draw it more out of line with each repeated heating and cooling and permanent distortions would be produced to a greater extent when the cooling was sudden, as by admission of much cold air through the fire-door for the purpose of checking a hot fire.

States Having Workmen's Compensation Acts—In what states have workmen's compensation acts been passed?

S. K. C.

To this date Workmen's Compensation Acts have been adopted by 30 states, as follows: Arizona, California, Colorado, Connecticut, Illinois, Indiana, Iowa, Kansas, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New York, Ohio, Oklahoma, Oregon, Rhode Island, Texas, Vermont, Washington, West Virginia, Wisconsin and Wyoming. In addition to these an act was passed by the State of Kentucky, but was declared unconstitutional.

Standards of Hardness of Water—What is the basis upon which the degree of hardness of water is designated?

J. B. R.

Hardness of water is usually designated according to one of the following standards of hardness:

French—Milligrams of calcium carbonate in 100 grams of water or parts per 100,000 of water.

German—Milligrams of lime in 100 grams of water, or parts per 100,000 of water.

English—Grains of calcium carbonate per Imperial gallon of 70,000 grains.

American—Grains of calcium carbonate per U. S. gallon of 58,381 grains.

Power Required for Operation of Pump—For raising water to an elevated tank, what horsepower will be required to operate a 7x10-in. pump making 95 strokes per minute with a suction lift of 8 ft. and working against a pressure of 70 lb. per sq.in., allowing for 15-per cent. slippage and 22 per cent. of the power lost in friction?

K. C.

With 15-per cent. slippage the effective length of stroke of the pump would be 85 per cent. of 10 in., or 8.5 in. A suction lift of 8 ft. would be equivalent to overcoming pressure of the atmosphere of

$$8 \times 0.434 = 3.47 \text{ lb. per sq.in.}$$

which, together with the discharge pressure, would amount to

$$3.47 + 70 = 73.47 \text{ lb. per sq.in.}$$

pressure overcome by the piston. The area of piston being

$$7 \times 7 \times 0.7854 = 38.4846 \text{ sq.in.}$$

the work performed in lifting the water would be

$$38.4846 \times 73.47 \times \frac{8.5}{12} \times 95 = 190{,}264.73 \text{ ft.-lb. per min.}$$

or at the rate of

$$190{,}264.73 \div 33{,}000 = 5.76 \text{ hp.}$$

With 22 per cent. of the applied power lost in friction, the power required for operation of the pump would be

$$\frac{5.76}{1.00 - 0.22} = 7.38 \text{ hp.}$$

Torsional Deflection of Iron Shaft—What would be the torsional deflection of a vertical iron shaft 10 in. diameter and 150 ft. long, running 200 r.p.m. and transmitting 1350 hp.?

G. H. R.

The angle of torsion is given in degrees by the formula,

$$A = \frac{583.6 \text{ P a l}}{d^4 G}$$

in which

l = Length of shaft (inches),

d = Diameter (inches),

P = Force (pounds) applied at the extremity of a lever arm = a in inches,

Pa = Twisting moment,

G = Modulus of torsional elasticity, which for an iron shaft would be equal to about 10,000,000.

Transmitting 1350 hp. at 200 r.p.m., the foot-pounds would be

$$\frac{1350 \times 33{,}000}{200} = 222{,}750 \text{ ft.-lb. per revolution,}$$

and the twisting moment, Pa, in inch-pounds would be

$$\frac{222{,}750 \times 12}{2\pi} = 425{,}420$$

As l, the length of shaft, is 150 ft. = 1800 in., and d, the diameter, 10 in. ,then by substitution the formula becomes,

$$A = \frac{583.6 \times 425{,}420 \times 1800}{10^4 \times 10{,}000{,}000} = 4.47 \text{ deg.}$$

which on the circumference of a 10-in. diameter shaft would measure

$$4.47 \times \frac{10 \times 3.1416}{360} = 0.39 \text{ in., or about } \frac{3}{8} + \frac{1}{64} \text{ in.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Missouri N. A. S. E. State Convention

Members of the National Association of Stationary Engineers in Missouri held their annual state convention May 19-21 at the Planters Hotel in St. Louis. With the 40 delegates and a number of visiting engineers from the vicinity, the attendance was up to normal. At the opening session, Wednesday morning, Associate City Counselor Charles H. Davies, in behalf of Mayor Kiel, welcomed the delegates to the city. In the response Fred W. Raven, national secretary, summarized briefly the aims and policies of the organization and the benefits to be derived from the practical education available to the members. Referring to Missouri's well-known motto, he suggested that the "me" be changed to "them." In other words, the members should show others the benefits to be derived from, and get them into, the organization. First of all, more interest must be taken in the work. Missouri has been drifting, and if she is to keep pace with her progressive neighbor, Kansas, there is urgent need of good work in the state. More enthusiasm, individual effort and the election of active officials were the things most needed.

J. H. Van Arsdale, past-national vice-president, reminded the engineers that they were assembled for the purpose of collectively seeing what could be done for the benefit of the organization. It stood for education, and many benefits could be derived from membership if advantage were only taken of opportunities available. Although national officers were doing all they could to improve the official paper there was need of the assistance of the engineer. The latter was not doing justice to the paper when he failed to credit its advertising pages as the source of inquiries for power-plant products. State President Daggett responded, urging a full attendance in the exhibit hall. The convention was then formally opened and the usual committees appointed.

MISSOURI N. A. S. E. DELEGATES ASSEMBLED AT ST. LOUIS

Routine business occupied the afternoon session. In the evening a get-together banquet proved a great success. Afterward, the diners retired to the exhibit hall and joined in favorite selections from the official songbook.

Much of the Thursday morning session was taken up by a discussion on the needs of the state organization. The advisability of discontinuing the convention, holding it at less frequent intervals or perhaps combining with Kansas, was considered. That general opinion favored continuance along the usual lines was evidenced on Friday when Kansas City was chosen as the convention city for 1916.

Thursday afternoon was featured by an inspection trip through the Anheuser-Busch Brewery and the manufacturing plant of the Busch-Sulzer Bros. Diesel Engine Co. In the evening an illustrated lecture by E. A. Garrett on the product of the latter company drew a large attendance.

On Friday morning news of the death of C. H. Huntington, president of St. Louis No. 2, was received with many manifestations of sorrow. The convention drew up suitable resolutions and authorized a presentation of flowers. Only necessary business was completed and all entertainment features on the program, such as a vaudeville entertainment listed for that evening, were eliminated. The following officers were elected and installed: L. Kjerluff, president; Charles Parkinson, vice-president; Rice Nance, secretary; F. H. Munsberg, treasurer; F. Middleton, conductor; Jacob Newpert, doorkeeper; Fred Key, trustee; S. J. Hunt, deputy, and L. Kjerluff, assistant deputy.

The companies represented in the unusually good exhibition and those who contributed follow:

The V. D. Anderson Co.
Arrow Boiler Compound Co.
Baumes-McDevitt Machinery Co.
A. Leschen & Sons Rope Co.
The Lunkenheimer Co.
James P. Marsh & Co.
George F. Matthews & Co.
Bennett-Dreyer-Buss Belting Co.
Big Muddy Coal & Iron Co.
C. J. & F. E. Briner.
Broderick-Bascom Rope Co.
Busch-Sulzer Bros.-Diesel Engine Co.
Clement-Restein Co.
Commercial Electrical Supply Co.
Crandall Packing Co.
Crane Co.
Dearborn Chemical Co.
Donk Bros. Coal & Coke Co.
The Edward Valve & Mfg. Co.
Walter L. Flower Co.
The Garlock Packing Co.
Greene, Tweed & Co.
Hawkeye Compound Co.
Heine Safety Boiler Co.
Price Hill.
Home Rubber Co.
H. W. Johns-Manville Co.
Kayser Tanning Co.
Keystone Lubricating Co.
Kupferle Bros. Mfg. Co.
Modern Engineering Co.
Morse Engineering Co.
Mound City Oil & Supply Co.
Mount Olive & Staunton Coal Co.
"National Engineer"
New York Belting & Packing Co.
Otis Elevator Co.
The P.-K. Engineers.
The Peerless Rubber Co.
Pierce Oil Corporation.
The William Powell Co.
"Power."
Reeves & Skinner Machinery Co.
Ridgway Dynamo & Engine Co.
St. Louis Pneumatic Tool & Supply Co.
F. C. Schwaner & Co.
Spencer Turbine Cleaner Co.
Standard Oil Co.
Western Boiler Compound & Chemical Co.
Western Valve Co.

Massachusetts Licensing Act Passed

Governor Walsh of Massachusetts signed an act on May 17 (Chapter 259) relative to the licensing of engineers and firemen, following extended discussion of this subject by the present Legislature. The act retains the supervision exercised by the boiler-inspection department of the district police over steam boilers and engines, licenses, examinations, etc. Its definitions of classes of licenses are of chief interest.

The act provides a nine-horsepower limitation on the size of boilers and engines that may be operated without a license, with the well-known exception of boilers and engines of locomotives, motor vehicles, residences and agricultural power units. Under its terms, to be eligible for examination for a first-class fireman's license, a person must have been employed as a steam engineer or fireman in charge of operating boilers for at least a year, or must have held and used a second-class fireman's license for not less than six months. To be eligible for examination for a third-class engineer's license, a person must have been employed as a steam engineer or fireman in charge of operating boilers for not less than one and one-half years, or must have held and used a first-class fireman's license for at least one year.

To be eligible for examination for a second-class engineer's license a person must have been employed as a steam engineer in charge of a plant having at least one engine of over 150 hp. for not less than two years, or he must have held and used a third-class engineer's license either as an engineer, assistant engineer or fireman for not less than one year, or have held and used a special license to operate a first-class plant for not less than two years; except that any person who has served three years as apprentice to the machinist or boiler-making trade in stationary, marine or locomotive engine or boiler works and who has been employed for one year in connection with the operation of a steam plant, or any person graduated as a mechanical engineer from a duly recognized school of technology, who has been employed for one year in connection with the operation of a steam plant, shall be eligible for examination for a second-class engineer's license. A person must have been employed for not less than three years as a steam engineer in charge of a plant having at least one engine of over 150 hp., or he must have held and used a second-class engineer's license in a second-class or first-class plant for not less than one and one-half years.

Licenses shall be distributed as follows:

Engineer's licenses: First-class, to have charge of and operate any steam plant; second-class, to have charge of and operate boilers or engines, no one of which shall exceed 150 hp., or to operate a first-class plant under the engineer in direct charge; third-class, to have charge of and operate boilers not exceeding 150 hp. in the aggregate, or engines not exceeding 50 hp. each, or to operate a second-class plant under the engineer in direct charge; fourth-class, to have charge of and operate hoisting and portable engines and boilers; portable class, to have charge of and to operate boilers and portable engines except hoisting and steam fire engines; steam fire engineer's class, to have charge of and to operate steam fire engines and boilers.

Firemen's licenses: Extra first-class, to have charge of and operate any boiler plant; first-class, to have charge of and to operate any boiler where the safety valve is set to blow at a pressure not exceeding 25 lb. per sq.in., or to operate high-pressure boilers under the engineer or fireman in direct charge thereof; second-class, to operate any boiler under the engineer or fireman in direct charge thereof. A person holding an extra first-class or first-class fireman's license may operate a third-class plant under the engineer in direct charge of it.

Special license: A person who desires to have charge of and operate a particular steam plant may be examined for such a license, but no engine of over 150 hp. is to be operated by such a person except where the main power plant is run by water power exclusively during the major part of the time and has auxiliary steam power for use during periods of low water.

Coming Pennsylvania State N. A. S. E. Convention

The annual convention of the Pennsylvania N. A. S. E. will meet at Pittsburgh, June 18 and 19. Headquarters will be at the Monongahela House, where all sessions are to be held. State President J. D. Rostron, of Chester, Penn., will preside. The other state officers are: P. O. Johnson, Philadelphia, vice-president; R. B. Ambrose, Pittsburgh, secretary, and D. E. Seeley, Dubois, treasurer. The committee in charge of the local arrangements for the convention is made up from the membership of the three Pittsburgh associations. This committee, of which George A. Bu Miller is chairman and L. S. Evans (care Lawrence Paint Co., Pittsburgh), is secretary, is preparing an elaborate entertainment and inspection program.

PENNSYLVANIA N. A. S. E. OFFICIALS

Jas. D. Rostron, State President (center); P. O. Johnson, State Vice-President (left); and R. B. Ambrose, State Secretary (right)

New Jersey N. A. S. E. Convention

The state convention of the New Jersey National Association of Stationary Engineers will be held in Masonic Hall, Warren and State St., Trenton, June 3 to 6, inclusive. Delegates' headquarters will be at the Trenton House, opposite the exhibit hall. A large attendance is expected on account of Trenton being a central location.

J. F. Lightford, president of Trenton No. 4, N. A. S. E., is chairman of the executive committee; William Hirst, vice-chairman; William W. Law, treasurer; E. A. Corbett, secretary.

New Johns Hopkins Buildings Dedicated

After the general exercises dedicating the new engineering building and power plant of the Johns Hopkins University, at Homewood, Baltimore, Md., an inspection tour through the engineering laboratories and power station was arranged for the evening of May 21. A short talk was given by the heads of the various departments, explaining the main features of the work under their charge, closing with a few general remarks by the newly installed president, Frank Johnson Goodnow, lately constitutional advisor to the Chinese Government. Instruction in mechanical engineering is in charge of Prof. Carl Clapp Thomas, M. E.; that in civil engineering is directed by Prof. Charles Joseph Tilden, S. B., and in charge of the department of electrical engineering is Prof. John Boswell Whitehead, Ph.D.

The power-station equipment is used as far as possible for both instructive experiments and supplying heat and electric current for the buildings. The steam and electric distributing systems are in light, roomy tunnels, which also afford convenient passageways from building to building.

In the power station are four B. & W. type water-tube boilers, each having 2640 sq.ft. of heating surface and carrying 125 lb. pressure. They are equipped with automatic feed-water control, high- and low-water alarm, and in the brick setting there are openings for thermometers, draft gages, CO_2 recorders. Under two boilers there are underfeed (Taylor) stokers and under the other two overfeed (Roney) stokers. The air supply from the fan to the stokers is measured by a Thomas recording gas meter, designed by Professor Thomas, and an accurate record may be made of the air supply to check with the flue-gas analysis.

The brick chimney, 160 ft. high and 7 ft. in diameter, has openings at various points (and convenient staging or balconies) from which gas samples may be obtained, and also the temperature and velocity determined.

By using Orsat flue-gas apparatus, of which there are two side by side, one a German type and the other American, the composition of the flue gas may be determined and the degree of efficiency of the furnace operation indicated. A Pintsch CO_2 recorder, which is a new and interesting development, takes samples of gas from the breeching just below the damper. It passes through a dry excelsior purifier, then enters a cooling coil that is jacketed by the water used to operate the ejector. This brings the gas to a constant temperature. It next passes through a small precision gas meter containing light mineral oil and then through an absorber, where the CO_2 is removed. The absorbing agent is slaked lime mixed with sawdust to keep it porous. This can be readily renewed once a week at very small cost. After leaving the absorber the gas passes through another cooling coil to remove the heat generated by the absorption of the CO_2 and is then directed through a second precision gas meter. The siphon ejector is placed after the second meter. The first meter measures all the gas; the second measures a lesser quantity by the amount of CO_2 absorbed, and therefore runs slower. A differential gear and mechanism transmutes this speed difference into vertical pen motion and makes a record on the chart. The pen is released and makes a dot on the chart for every cubic foot passing, its relative position indicating the percentage of CO_2. The coal- and ash-handling systems are so arranged that during tests accurate weights may be taken.

From the boilers the steam may be led through an independently fired superheater to the engines or by a direct line in a saturated state, so as to demonstrate the effect of superheat on the efficiency and steam consumption in the engines under various conditions of operation.

In the main engine room there are three units: A Harrisburg four-valve reciprocating engine rated at 150 hp. at 200 r.p.m., directly connected to a Westinghouse 100-kw., 250-volt generator. A Kerr (Economy) turbine, connected to an Allis-Chalmers 100-kw. generator; and a Westinghouse turbine set. All of these are so piped that the exhaust steam may be used for heating the buildings or may be directed to a Wheeler surface condenser having 300 sq.ft. of cooling surface capable of condensing 2500 lb. of steam per hour with cooling water at 70 deg. The condensation may be led to the weir tanks and measured. The cooling water also is measured by a venturi meter.

In another part of the building a Nash producer-gas engine rated at 14 hp. is supplied by a Smith suction gas producer using anthracite coal, which gives the student an idea of the general requirements of such apparatus.

A Diesel-type crude-oil engine loaned by the Allis-Chalmers Manufacturing Co. is used for experimental purposes. It is equipped with special attachments for testing and is capable of using almost any kind of clean liquid fuel.

On the floor above, a Buckeyemobile engine, directly connected to a 75-kw. generator, represents the latest development in a self-contained steam unit of remarkable efficiency. Various other equipment connected with the heating and ventilating operation, and meters, oil testers, calorimeters, etc., give the student a comprehensive insight into actual power-plant management and, together with extensive laboratory equipment, make it possible for the instructor to demonstrate the latest practice in engineering.

PERSONALS

Walter R. Johnson is no longer associated with the Harrison (Cochrane) Safety Boiler Works. He was formerly Southern representative, with headquarters at Atlanta, Ga.

H. D. McCaskey has been designated as statistician in charge of the Division of Mineral Resources, U. S. Geological Survey, succeeding Edward W. Parker, resigned, as noted elsewhere. Mr. McCaskey was a mining engineer in the Philippine Mining Bureau from 1900 to 1906, and has been with the Geological Survey since 1907. He will also continue his work upon the metallic resources of the United States.

Edward W. Parker, statistician in charge of the Division of Mineral Resources, U. S. Geological Survey, and for many years the Government coal statistician, leaves the Government service July 1 to accept a responsible position with the anthracite mining interests. Director George Otis Smith, of the Survey, has gone on record as expressing his regret at this termination of Mr. Parker's long and efficient service, which, in addition to the work mentioned, has comprised a study of coal testing and conservation and the publication in the engineering press of many papers on coal mining and production.

ENGINEERING AFFAIRS

The Worcester Polytechnic Institute will celebrate its fiftieth anniversary June 6-10. The dedication of a new gymnasium, a special meeting of the American Society of Mechanical Engineers to be held at the works of the Norton Co., and the annual commencement exercises are among the events scheduled. President Wilson, who was the commencement orator twenty-five years ago, has expressed a desire to be present, and it is hoped that the pressure of public business may permit his attendance. Gen. George W. Goethals has already accepted an invitation to be present.

NEW EQUIPMENT

ATLANTIC COAST STATES

Bids will be received until June 1 by the Children's Institution Department, Boston, Mass., for a 15-kw. direct-connected engine and generator at Rainsford Island. John O'Hare is Comr.

The town of Milford, Mass., is considering the purchase of the plant of the Milford Electric Light & Power Co. William Plattner, Attleboro, has been retained to appraise the value.

At a recent town meeting in Sterling, Mass., an appropriation of $5900 was made for extending the transmission lines of the municipal electric-lighting system as follows: Camp grounds at Sterling Junction, $2600; Rowley Hill district, $2000, and to the Chocksett district, $1300. H. W. Rugg is Mgr. and Supt. of the municipal plant.

Bids will be received until June 1 by C. B. J. Snyder, Supt. of School Buildings, Park Ave. and 59th St., New York, N. Y., for additions, alterations and repairs to the electrical equipment in Public Schools 25, 31, 44, 62, 177 and 188, Borough of Manhattan.

It is reported that the Crucible Steel Co. of America, Harrison, N. J., will build a new power station on Cumberland St. in connection with the extensions to its plant.

The Atlas Finishing Co., Homestead, N. J. (West Hoboken post office), plans to build a one-story power house.

The Toms River & Island Heights Electric Light & Power Co., Toms River, N. J., will soon install one 125-hp. Coatesville boiler in its plant. C. A. Brant is Secy. and Mgr.

The Borough Council of St. Clair, Penn., is considering plans for improving the municipal electric-light plant. J. J. Hughes is Mgr. of the plant.

The City Council of Cumberland, Md., is reported to be considering improvements to the municipal electric-lighting system at an estimated cost of $15,000. A high-speed steam turbine, directly connected, will be installed, and the present street-lamps will be replaced by new ones. James P. Gaffney is City Engr.

SOUTHERN STATES

According to press reports, the North Carolina Electrical Power Co., Asheville, N. C., plans to build a steam-driven auxiliary electric plant on the French Broad River to cost about $150,000. Generating equipment for 4000 hp. will be installed this year. W. T. Weaver, Asheville, is Pres. and Mgr.

At a recent election the citizens of Waynesville, N. C., voted in favor of issuing $25,000 in bonds to be used for the installation of a municipal electric-light plant.

Bonds in the sum of $10,000 have been voted by the citizens of Gleason, Tenn., for the construction of a municipal electric-light plant.

The Lancaster Electric Light Plant, Lancaster, Ky., will increase the equipment of its plant to provide 24-hr. service for the town. Alex Walker is interested.

CENTRAL STATES

Press reports state that the City Council of Oberlin, Ohio, is considering the installation of a municipal electric-light plant and water-works system.

It is reported that the new Alhambra Theater, Sandusky, Ohio, will be equipped with an independent electric-light and power plant. The equipment will include a 90-hp. Bruce-McBeth engine and a 50-kw. generator, directly connected.

It is reported that the Western Drop Forge Co., Marion, Ind., will increase its power plant by the addition of 700 hp.

WEST OF THE MISSISSIPPI

Bids will be received until June 7 by the Town of Alta Vista, Iowa, for the construction of an electric transmission line and a distribution system for the town. F. Rabe is Town Clk.

The town of Charter Oak, Iowa, has sold bonds, the proceeds of which will be used for the installation of a municipal electric-light plant.

A special election will be held in Lake City, Iowa, to vote on the question of granting a 25-year franchise to the Central Iowa Light & Power Co., Boone, to furnish electricity for lamps and motors in Lake City.

The City Council of Wilton Junction, Iowa, has rejected the offer made by the Davenport & Muscatine Ry. Co., Davenport, to build a transmission line to Wilton Junction, and will rebuild the municipal electric plant. George Bannock is Mayor.

Preliminary plans are being prepared for the installation of a municipal electric-lighting system for the town of Muscotah, Kan.

It is reported that the Texas Southern Electric Co., Victoria, Tex., has purchased the electric-light and ice factory of the City Ice & Electric Co., Del Rio, Tex. The reported purchase price is $90,000. The new owners will improve the property.

Bids will be received until June 3 by Wilson & Cutting, Engrs., 325 Electric Bldg., Butte, Mont., for the installation of an electric-heating system (indirect with fan) in the High School at Burley, Idaho. The building contains 40 rooms.

The plant of the Morton Electric Co., Morton, Wash., owned by F. M. Broadbent, has been sold to C. O. Smith of Pe Ell, Wash., at approximately $20,000. The plant will be enlarged and improved at once.

It is reported that the West Virginia Mining Co., operating the Lone Surprise mine at Republic, Wash., will install a 200-hp. compressor, a new Diesel engine and an electric hoist.

POWER

Vol. 41 NEW YORK, JUNE 8, 1915 No. 23

Candid Chats

The Power of Ambition

Do you want to be more successful, earn more money, occupy a better position in life? You can do it. Your life is in your making. Be you what you may, you can rise to a height limited only by your ambition and your energy.

You say you are now putting in the better part of the day in a hot and stuffy power plant. That should not deter you. You are AMBITIOUS. Can't you feel an invisible something forcing you upward, almost against your conscious will, continually urging you onward and onward? You know that to attain a higher position, you will have to make yourself more valuable to your employer and to the world. One way to do this is to study good books; subscribe to the best technical magazines; so that you may keep informed of the latest progress in your business.

BE YOU *what you may, you can rise to a height limited only by your ambition and energy.*

Your limit is not the Chief Engineer's desk. It is but a step from that to an executive position. Once you start working in earnest, you will be surprised at THE POWER OF AMBITION.

Every circumstance will be a spur and an incentive to greater effort; if adverse, it will only make you clench your teeth and fight the harder. But first you must fix in your mind what object you are going to attain; choose a definite goal, so that you can concentrate all your efforts toward it.

In this fight for advancement, it is very much as in actual warfare — once the general discovers where the enemy lies hidden, he can muster all his forces to overcome them, without having to spread them over a large area with the consequent weakening of his power.

Be sure to set your mark high enough. "Hitch your wagon to a star." And above all, don't allow yourself to become discouraged at the first obstacle you meet.

Any weakling can lie down and quit, but it takes a MAN to be up and at it when he encounters an obstruction in his path to success. Just as the athlete becomes stronger by continued physical exertion, so you will become stronger in character by overcoming the obstacles confronting you.

Now then, FIRE UP! See what you can do!

(Contributed by Herman Block, Brooklyn, N. Y.)

Power Plant of New Lumber Exchange Building

By Thomas Wilson

SYNOPSIS—A direct-current plant with 600-kw. generating capacity and 800 hp. in Scotch marine boilers. Engines equipped with poppet valves operated by eccentrics on a layshaft. Small steam piping and large receiver separators a feature. An excellent switchboard on which vertical circuit-breakers replace the usual switches and fuses on feeder panels. Gravity ventilation for engine and boiler rooms.

On May 2, 1914, the work of tearing down the old Roanoke Building at the corner of Madison and La Salle St., Chicago, was started, and at the present writing the Lumber Exchange Building, which has taken its place, is practically complete. The latter structure is a 16-story office building, 217 ft. tall from sidewalk to cornice, erected by the L. J. McCormick estate. The steelwork was designed for 20 stories, and the supporting risers have been carried through the roof, so that if desired an extension may be easily made at any time. Below the sidewalk there is a basement and two sub-basements containing the engine and boiler rooms, the floor of the latter being 45 ft. below the street level. The two levels for the power plant were necessary, as the adjacent building rests on a floating foundation, within 30 ft. of which deep excavation was not permitted. The frontage on La Salle St. is 135 ft. and on Madison St. 101 ft. At the inner corner a 47x75-ft. light-shaft above the third floor reduces the outline to an L shape. The building is of substantial construction throughout and, with its artistic terra cotta exterior, presents a handsome appearance.

To supply this building with heat, light, and power for the electric elevators is the purpose of the power plant located in the sub-basements. This plant contains a number of interesting features such as are indicated in the synopsis. Generally speaking, it is substantial and uptodate in every respect. For the services for which it is intended the plant has been laid out to operate at high economy, and a special effort has been made to hold the labor and maintenance items to a minimum.

It has been estimated that the load will run close to 300 kw. during the heating season and up to 200 kw. in the summer months. Consequently, units of these capacities and four boilers rated at 200 hp. each were installed. At any one time two of these boilers will easily supply sufficient steam for the generating units and there will be two in reserve. Exhaust steam will be used for heating, and to furnish a sufficient supply during nights and holidays a specially designed 100-kw. turbo-generator with a high water rate will carry the load.

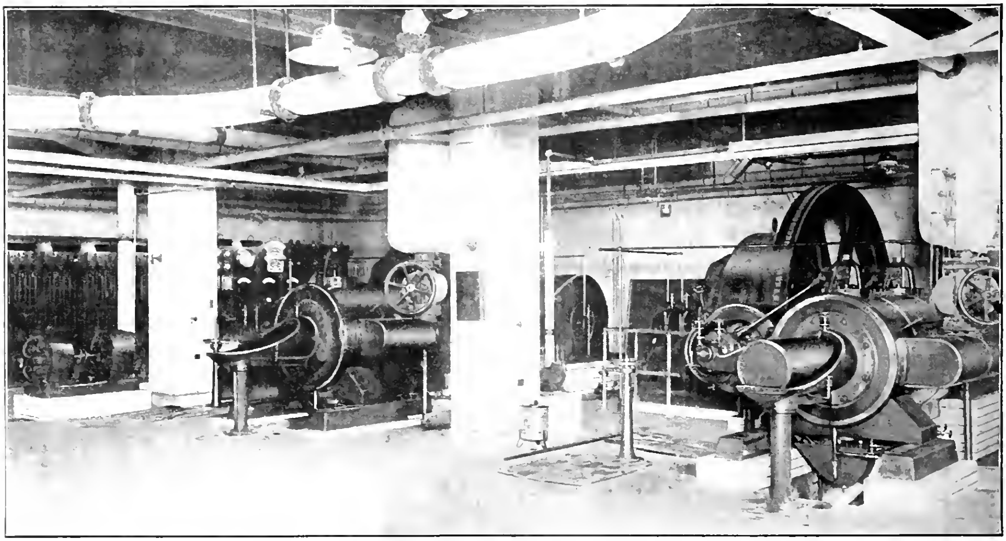


Fig. 1. Engine Room of Lumber Exchange Building

Boiler Installation

After due consideration of the magnitude and variable character of the load, it was decided to install units of 200-hp. capacity. These boilers are of the Scotch marine dry-back type, 96 in. in diameter and 16 ft. long. By means of a sheet-iron thimble lined with firebrick each boiler is connected with a dutch-oven furnace equipped with a top-feed stoker. Eventually, the air supply for the furnace will be drawn around this thimble and introduced into a closed ashpit. The stoker is provided with crushing rolls at the bottom of the magazines, which not only crush the coal, but also force it onto the grates. The latter are V-shaped and are inclined at an angle of 45 deg. The actual grate surface is 53 sq.ft. and 50 per cent. of this is air space. To the 1595 sq.ft. of heating surface in the boiler, the grate area bears a ratio of 30.1 to 1. This is considerably lower than commonly allowed, but the boilers are rated on 8 sq.ft. of surface per horsepower and the large air space in the grate permits a high rate of combustion.

The boilers are designed for 200 lb. pressure, but are operated at 160 lb. gage. They are covered with magnesia block, and with a handhole on each side and one on the top of the boiler, are easily accessible so that cleaning may be effected in a comparatively short time. There is diameter, but a 4-in. lining all the way up reduces the bore to 5 ft. 4 in. A powerful draft is thus available, and the proper intensity over the fire is obtained by damper control. Differential draft gages with four connections—one to the ashpit, one over the fire, one at the rear of the boiler and one to the uptake—make it possible to read the draft at the particular points just mentioned or the drop in draft through the furnace and boiler. The smoke flue, which is immediately in front of the boiler and runs over the rear ends of the furnaces, is of tapering section. It has one right-angled turn and at the stack its area is 27 sq.ft. This may be compared to 22 sq.ft., the free area of the stack, and to a connected grate surface of 212 sq.ft.

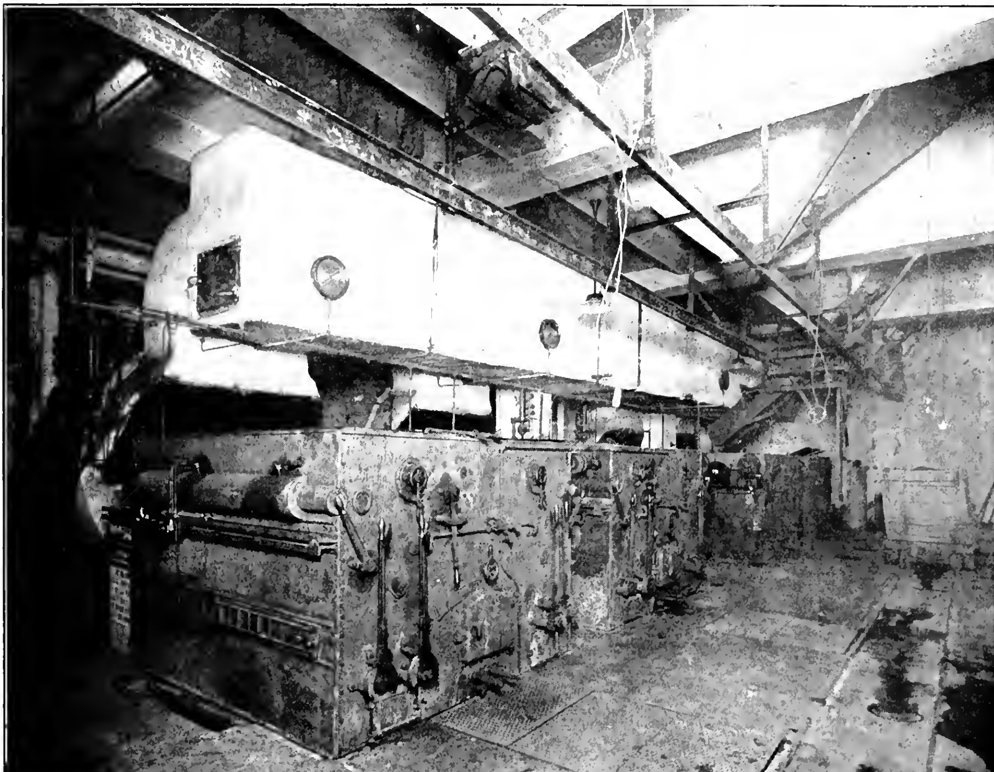


Fig. 2. Boiler Installation with One of Tunnel Cars at the Right

little loss from radiation. The boilers will hold their heat well over night and by the omission of the usual brick setting air infiltration is obviated. High economy should be obtained, and with a furnace which can be hand-fired if necessary, reliable and continuous service may be expected. It is planned to run two boilers during the day and bank one at night. By forcing, one boiler might handle the load, but two are carried on the line to guard against a possible interruption of the service. A point worthy of consideration is that all repair parts that these boilers may need can be conveyed to the boiler room through the elevator shaft.

Natural draft is supplied by a steel stack rising about 300 ft. above the boiler-room floor. The shell is 6 ft. in To the last figure the breeching area bears a ratio of 1 to 8, but as it is not expected that more than two boilers will be operated at any one time, the ratio actually becomes 1 to 4, which is close to standard practice.

Feed water may be drawn from the heater or the city mains and is forced to the boilers by either one of two simplex pumps. To guard against interruption of the feed, the supply lines to the boilers are in duplicate and are cross-connected so that parts of either line may be cut out of service if desired. Provision has also been made for weighing tanks to be used in testing the boilers or as a check on the V-notch meter.

Illinois screenings is used as fuel. It may be delivered by wagon or through Chicago's underground freight tunnel. There are four chutes from La Salle St., each discharging to a 50-ton reinforced-concrete bunker, one for each boiler. When the coal is delivered through the tunnel, the cars are run in on the boiler-room floor and dumped into a hopper beside the track. From this hopper a screw conveyor forces the coal to a bucket elevator, which at the top of the boiler room turns at right angles and delivers the coal to any one of the four bunkers. In the horizontal run the buckets scrape the coal along a

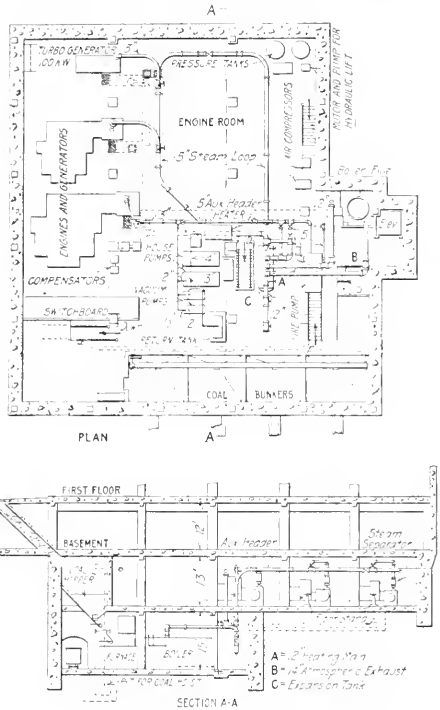


Fig. 3. Plan of Engine Room and Elevation through Plant

trough and through gates in the bottom of this trough, which are operated by handwheels in the engine room, and discharge it to any one of the bunkers. A track scale weighs the coal on its way to the magazines of the stoker. Ashes are shoveled directly into the tunnel cars, which at stated intervals are removed from the plant.

To prevent spoiling the fires in the boiler furnaces, a rubbish burner has been provided. This is a hot-water boiler with a coal grate below and a tube grate above for the paper and other waste from the building. Water for house service passes through this boiler and absorbs the heat from the waste material. Additional heat is supplied by closed heaters in the engine room, provided with exhaust-steam connections and temperature regulators.

From the third floor down all sewage must be raised to the street. For this purpose a duplex motor-driven sewage ejector has been provided in the boiler room. To care for an excessive quantity of water, a turbine-driven centrifugal pump with a 10-in. suction and 5-in. discharge, has been installed. The sewage must be elevated about 40 ft.

In the selection of the generating units, economy and regulation were the first considerations. With an electric-elevator load the variations are excessive and close regulation is necessary to prevent the fluctuations showing in the lights. Poppet four-valve engines were chosen as the prime movers for the two larger units. The valves are of the balanced type and are positively operated by cams oscillated by eccentrics on a layshaft. Between the two eccentrics an inertia governor mounted on the layshaft controls the speed. On its way to the inlet valves the steam passes over the ends of the cylinder, tending to reduce initial condensation and increase the economy of the engine.

For these units, which are of 300- and 200-kw. capacity respectively, the guaranteed steam consumption at full load is 20.8 lb. per i.hp.-hr., but from results obtained from engines of the same type a lower rate is expected. The generators are two-wire, 240-volt machines specially provided with extra large air gaps and heavy series windings to care for the heavy inrushes of current caused by the electric-elevator load. Compensators provide for three-wire distribution on the lighting. The engines are equipped with an automatic oiling system with an overhead tank and drainage from the bearings to a filter in the boiler room. Cylinder lubrication is effected by three-feed pumps driven from the layshaft. One feed goes to the throttle and one to each end of the cylinder. A reducing motion attached to a standard on the guide barrel and driven by the crosshead is a permanent fixture of the engine.

During the summer months it is the intention to run the smaller engine unit. In the heating season the large

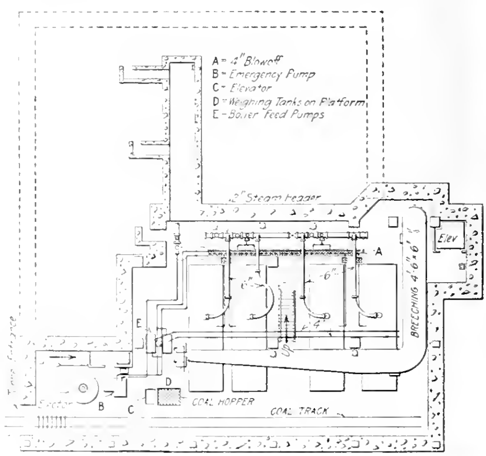


Fig. 4. Plan of Boiler Room below the Engine Room

unit will carry the load. From preliminary estimates it was figured that during the day there would be sufficient exhaust steam for heating, as in addition to the engines there are a number of steam-driven pumps. At night, however, and on holidays the load will be light, and rather than supply the live steam which would be necessary for heating through a reducing valve, it was deemed advisable to utilize a turbo-generator with a water rate purposely made high by the addition of nozzles so that sufficient exhaust steam would be available for heating. In other words, the turbine will act as a reducing valve and at the same time generate all of the current that is needed.

The unit consists of a 150-hp. single-stage turbine directly driving a 100-kw., 240-volt, direct-current generator at a speed of 2200 r.p.m. It was built especially to meet the requirements of the particular class of service existing in this plant. The governing device is so designed as to give practically constant speed under all conditions of load. At this writing the turbine has not been installed. A fuller description of this unit will be given when the results of the acceptance tests are available.

Piping Arrangement

From the accompanying line drawings the piping arrangement will be evident. Six-inch boiler leads connect with a 12-in. header at the rear of the boilers. Risers lead up to a 5-in. loop in the engine room and to an auxiliary header supplying the boiler-feed, fire, house and vacuum pumps. From this header there are also reducing-valve connections to the expansion tank, so that live steam may be supplied to the heating system when the turbine unit is not operating. If a large amount of live steam is required, the 5-in. reducing valve will be used. For a small quantity to supplement the exhaust-steam supply, a 1½-in. reducing valve has been provided. This relieves the larger valve and prevents the wire-drawing that would occur with a small quantity of steam passing through. The 5-in. loop now supplies the smaller engine and the turbine and is also intended for a 150-ton refrigerating machine which may be installed at some time in the future. All condensation from the loop and the auxiliary header returns directly to the main header in the boiler room, and from here it is trapped to the heater.

The remarkable feature about the piping is the small leads supplying the generating units. A 3-in. pipe supplies the 300-kw. machine, and the lead to the smaller engine is only 2½ in. in diameter. A 25-per cent. overload on the engines will require a steam velocity of about 8000 ft. per min. in these pipes. As standards go, this velocity might be considered excessive, but as the pipes are used in conjunction with receiver separators four times the volumes of the cylinders and large throttle valves, not the slightest trouble has resulted during the short time the plant has been in operation. The loop from which the small engine draws its supply is suspended from rings in the ceiling by means of turnbuckle hangers. It is not even anchored, and yet there is no evidence of vibration due to the cutoff of the engine. The reasons for this small piping are, of course, less radiation, less condensation and a lower initial cost for piping and fittings. As the engine throttles are 8 and 7 in. respectively, the supply of steam is not curtailed, and any inequalities in pressure which might result with the usual installation are smoothed out by the large separators.

Through a tunnel under the engine-room floor the exhaust piping passes out into the boiler room, thence up to the heater, which is on the engine-room floor, and on to the expansion tank and the hot-water heaters for house service. The relief valve to atmosphere is set for a back pressure of 2 lb.

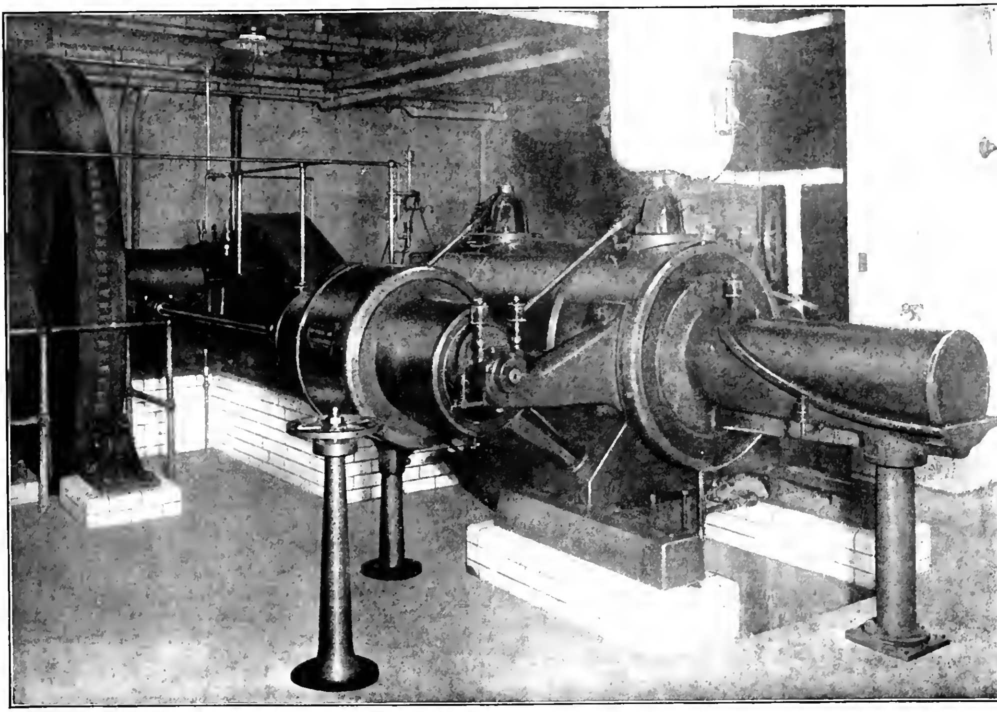


Fig. 5. One of the Poppet Four-Valve Engines

A feature of interest is the separation of the V-notch meter and the feed-water heater. The connections are so arranged that either may be cut out of service without affecting the other or both may operate independently; that is, the meter may measure the water to one boiler which is perhaps running on test, while the water for the other boilers is drawn directly from the heater. Piping connections have also been made so that the returns from the heating system or from any or all traps can be measured separately. Ordinarily, of course, the water passes from the heater to the meter, and with this independent arrangement the exact quantity is recorded just as it flows to the boiler. When the meter is installed in the heater, the flow over the V-notch may be greater or less momentarily than the amount of water fed to the boilers. The flow over the weir is the amount recorded on the chart, so that instantaneous readings and the actual boiler feed may not check, although either system over a period of time will record the same amount.

Another feature, not as common as it should be, is the provision of a small auxiliary pump to relieve the fire pump. Any slight unbalancing of pressure is cared for by the small pump. The fire pump is maintained ready for instant duty and is automatically cut into service when the capacity of its auxiliary is exceeded.

Heating and Ventilation

To heat the building, 21,108 sq.ft. of direct radiation has been provided. It is served by a vacuum system of the Van Auken type, with overhead distribution. Everything above the main floor is taken care of by a 10-in. riser that distributes downward from the attic on the seventh floor. A 5-in. pipe supplies the main floor and the basement.

Ventilation for the basement and the toilets is provided, and effected by motor-driven exhaust fans. The engine and boiler rooms depend on the pull of the stack for their supply of fresh air. Cold air from above is drawn down through the elevator shafts and stairways and in this particular case also through two ducts leading to gratings in the sidewalk. Fresh air passes across the engine and boiler rooms on its way to the furnaces, so that the rooms are maintained at a comfortable temperature. The stack has been erected in a square casing, with considerable clearance between the walls and the shell. Consequently, there is a free passage for the air from the boiler room to the roof, so that the ventilation is continuous whether the dampers to the furnaces are open or closed. The same system has been applied to the McCormick Building with wonderful success. The engine and boiler rooms are exceptionally cool. The air currents were studied by means of silk flags hung from wires stretched across the room. In this way the openings for air admission were properly located and any necessity for deflectors to send the air to all parts of the room was made evident. The same procedure must be followed in the new building under discussion. The air currents common to the building must be established, and proper methods adopted to produce uniform distribution and satisfactory ventilation.

To heat the hallways the same principle was applied, but this time utilizing the pull of the building. Vento coils are placed within inclosures off the hallways, and through grills fresh air from the street is drawn over the heating surface into the hallways. This relieves the dif-

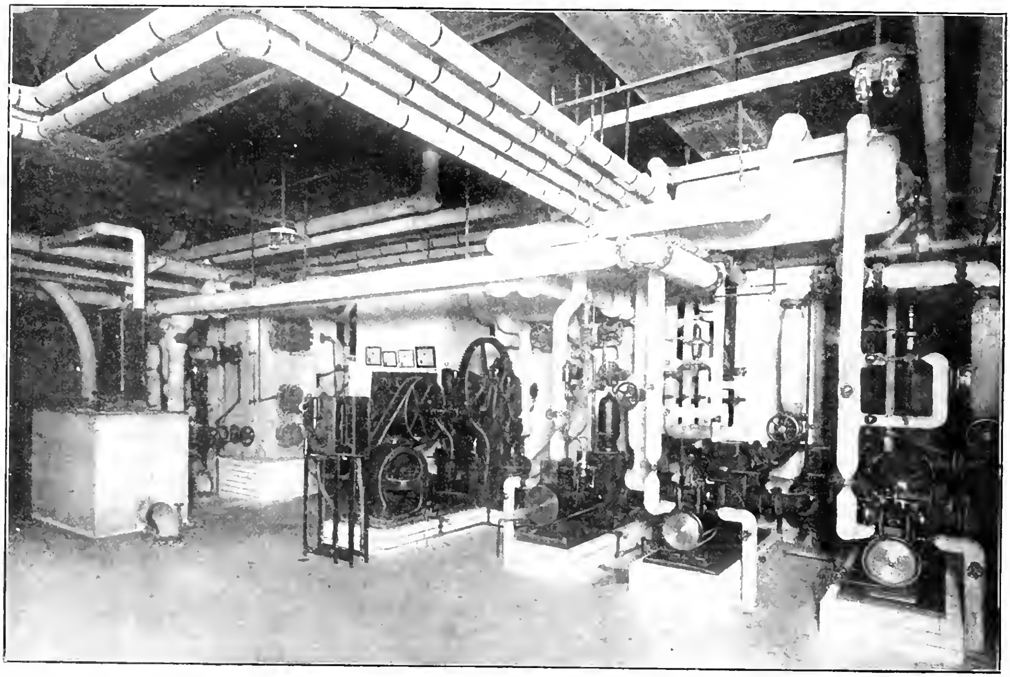


Fig. 6. Vacuum and House Pumps, Open Heater and V-Notch Meter

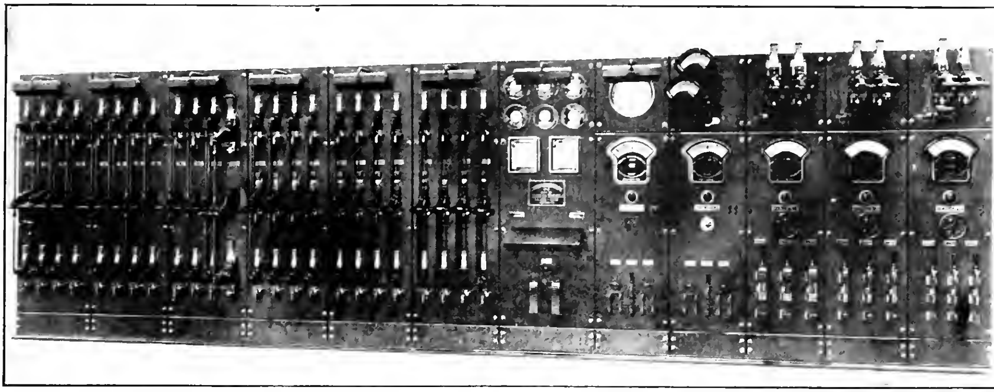


FIG. 7. FRONT VIEW OF SWITCHBOARD, SHOWING VERTICAL-TYPE CIRCUIT-BREAKERS

ference in pressure between the interior and the exterior of the building, and when the doors are opened no great quantity of cold air is drawn in. The hall is maintained at a satisfactory temperature, and in this regard the usual difficulties are eliminated.

ELEVATOR DETAILS

The elevators for the building are of the 1 to 1 gearless traction type. Five are passenger cars having a capacity of 2500 lb. at a speed of 550 ft. per min. The sixth elevator is for freight service. Its capacity and normal speed are the same, but heavy lifts may be effected at slow speed by the use of an extra 6000-lb. counterweight. All of the cars are driven by 220-volt, 31-hp. motors having a rated speed of 58.5 r.p.m. The cars have interlocking doors that must be closed to within 4 in. before motion is possible. There is also a special board for recording the stops and signals.

For service between the main floor and the basement there is a 1000-lb. hydraulic lift, operating on a water pressure of 125 lb. The equipment, consisting of pressure tanks, a motor-driven pump and a small air compressor belted to the pump shaft, is located in the engine room. Near-by is a small air compressor, which is motor-

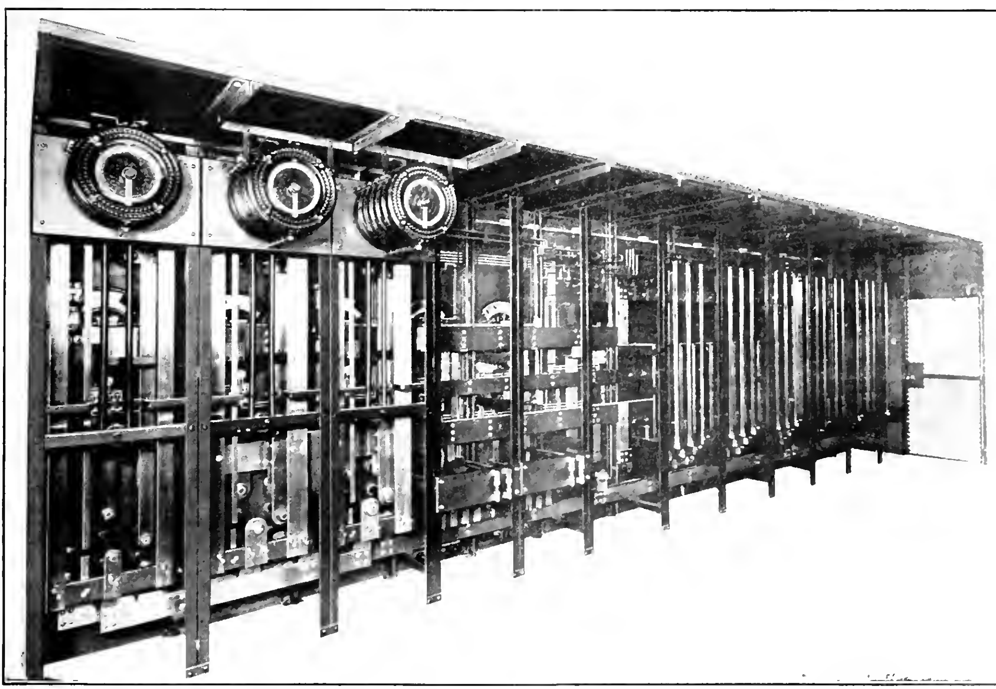


FIG. 8. REAR VIEW OF SWITCHBOARD, SHOWING SIMPLICITY OF COPPER WORK BEHIND FEEDER PANELS

driven and supplies air at 100 lb. pressure for blowing the dust from the switchboard, generators and other equipment of the plant.

Switchboard Equipment

The switchboard is an excellent example of a modern installation. It is equipped with the latest instruments and lighted by means of reflectors above the panels, but the feature which distinguishes it from the ordinary is the use of vertical-type circuit-breakers on the feeder circuits. These breakers are connected directly to the busbars so that intermediate connections and fuses are eliminated. This results in an unusually simple arrangement back of the board and effects a considerable saving in copper. The circuit-breakers are of the interlocking type, nonclosing on overloads, and as the busses may be run close to the board, studs of standard length are used.

For lighting, the distribution is three-wire and the power circuits are two-wire. As a consequence two- and three-pole circuit-breakers are employed, but for the sake of uniformity the positive poles at the top, the negative poles at the bottom and the operating handles at the center have all been placed in line. The generator panels are equipped with overload, no-voltage and time-limit release-type circuit-breakers in which the poles are arranged horizontally. The three busses are carried directly across the board to the lighting panels and independent positive and negative busses extend all the way across to the power panels. The two sets of busses are brought together by means of a suitable tie-switch. It is thus possible to carry the power and lighting loads on separate machines or on one machine, as desired. The lower stud of each breaker is connected to a bus. The upper stud is carried back of the bus, and a bar connection extends directly down to the terminal board. It may be noticed that all of the feeders terminate on panels at the bottom of the switchboard and that no flexible copper leads are used save those for the instruments. It is evident that the copper work is all straight-run and the arrangement unusually simple.

Frank H. Getchell, electrical engineer for Holabird & Roche, architects for the building, is the designer of the switchboard and the remainder of the electrical equipment. The mechanical equipment of the plant and building was laid out by John B. Blake, mechanical engineer for the same company, under the supervision of M. T. Kinman, chief engineer of the McCormick estate. C. G. Harding is the chief operating engineer in charge of the plant.

PRINCIPAL EQUIPMENT OF LUMBER EXCHANGE BUILDING PLANT

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Scotch-marine	200-hp.	Generate steam...	160 lb. press., natural draft stokers........	Springfield Boiler & Manufacturing Co.
4	Stokers.	Side-feed	53 sq ft. grate	Serve boilers.	45-deg grates, 50 per cent. air space........	McKenzie Furnace Co.
2	Pumps	Simplex. ...	7x6½x10-in.	Feed boilers.	160 lb. steam press.	(Marsh) American Steam Pump Co.
4	Draft gages.	Differential		Measure boiler draft	Four connections	L. M. Ellison
1	Rubbish burner...	Hot-water boiler		Burn waste from building	Water head 130 lb...	Kewanee Boiler Co.
1	Conveyor	Screw.	10 tons per hr...	Coal from hopper to elevator..	Motor-driven..	Webster Engineering Co.
1	Conveyor	Bucket.	10 tons per hr...	Coal from screw conv. to bunkers.	Motor-driven...	Webster Engineering Co.
1	Scale	Track		Weigh coal to furnaces		Webster Engineering Co.
1	Sewage ejector	Duplex-electric		Raise sewage to sewer...	Operated by 2 C.-W. 7.5-hp. motors	Yeomans Bros. Co.
1	Pump	Centrifugal	10-in. suction, 5-in. discharge	For emergency sewage....	Driven by Wait turbine	Henry R. Worthington
1	Engine.	Four-valve poppet	22x32-in.	Main generating unit	160 lb. steam, 150 r.p.m.	Nordberg Manufacturing Co
1	Generator....	Direct-current..	300-kw..	Main generating unit...	240 volts, 150 r.p.m.	Crocker-Wheeler Co.
1	Engine.	Four-valve poppet.....	18x36-in.	Main generating unit.....	160 lb. steam, 150 r.p.m.	Nordberg Manufacturing Co.
1	Generator..	Direct-current..	200-kw.	Main generating unit...	240 volts, 150 r.p.m.	Crocker-Wheeler Co.
1	Turbine	Single-stage impulse.	100-kw.	Main generating unit...	160 lb. steam, 2200 r.p.m.	H. H. Wait
1	Generator	Direct-current..	100-kw	Main generating unit...	240 volts, 2200 r.p.m.	H. H. Wait
2	Balance sets...		115 volts, 20 amp 115 volts, 40 amp	Balance three-wire system	1600 and 1150 r.p.m.	Crocker-Wheeler Co.
1	Switchboard*.	Slate..	12-panel...	Control and distribution current...		Cuthbert Electric Manufacturing Co.
24	Circuit breakers.	I.T.E. "Directite".		Feeder panels		The Cutter Co.
3	Circuit breakers.	I.T.E.		Generator panels		The Cutter Co
1	Heater	Sorge-Cochrane, open	500-hp.	Heat feed water	Exhaust steam	Harrison Safety Boiler Works
1	Meter..	V-notch		Record boiler feed		Harrison Safety Boiler Works
2	Heaters	Closed..	1200-gal. per hr.	Hot water for house	Exhaust steam	W. Baragwaneth & Son
2	Pumps	Vacuum..	8x12x12-in.	Heating system	160 lb. steam.	International Steam Pump Co
1	Pump..	Simplex......	7x6½x10-in.	House service	160 lb. steam, head 130 lb.	American Steam Pump Co.
1	Pump..	Triplex.	6x8-in..	House pump	Driven by 15-hp. C.-W. motor, 800 r.p.m.	Deane Steam Pump Co.
1	Pump.	Underwriters	14x7½x12-in..	Fire service	160 lb. steam	International Steam Pump Co.
1	Pump..	Duplex.	6x4x6-in...	Auxiliary to fire pump		International Steam Pump Co.
1	Air compressor	Single-stage.	8x8-in...	Comp. air for cleaning	Driven by 15-hp. C.W. motor, 800 r.p.m., 100 lb. press..	Chicago Pneumatic Tool Co.
6	Elevators.	1 to 1 gearless traction..	2500-lb.	Serve building.........	550 ft. per min., 34-hp. motors	Otis Elevator Co.
1	Lift.........	Hydraulic......	4000-lb.	First floor to basement	Water pressure 125 lb..	Otis Elevator Co.
1	Pump..	Triplex..	4x60-in.	Serve hydraulic elevator	Driven by 5-hp. C.-W. motor.	Deane Steam Pump Co.
1	Oiling system	Pump and gravity		Lubricate generating units	Filter, gravity tank and complete system....	Richardson-Phenix Co.
2	Cylinder lubricators.	Three-feed		For main engines.......	Driven from layshaft..	Richardson-Phenix Co.
7	Cylinder lubricators..			For steam pumps..		Richardson-Phenix Co.

*Weston ammeters and voltmeters, Sangamo wattmeters, Esterline graphic ammeter and voltmeter

B.t.u. to Calories—To convert B.t.u. per pound to calories per kilogram, divide the number of B.t.u. by 1.8; to convert calories per kilogram to B.t.u. per pound, multiply the calories by 1.8.

Pressure Drop in Steam Lines is comparable with line drop in electric distribution systems, which is known to be energy lost, but the desired terminal voltage is obtained and the drop compensated for by a slight increase of voltage at the source or apparatus designed to use the lower voltage. Feeders or steam lines large enough to cause no drop are not feasible; the amount of drop to be permitted is the variable quantity. The greater radiation loss from excessively large steam lines has no counterpart in the electric-distribution analogy.

Core Loss in Series Motor

By T. M. Robie

SYNOPSIS—The article describes a method of finding the core loss of a series motor by test with the aid of a motor-dynamometer.

The losses in a motor or generator are: The field loss *F*, due to the heat generated in the field windings by the field current; the armature loss *A*, due to the heat generated in the armature windings; the loss in the brushes; stray power loss *S*, which includes eddy current and hysteresis losses, chiefly in the armature core; and losses due to friction in the bearings, at the brushes, and windage, or air friction.

The heat losses can be calculated from the equation,

$$\text{watts lost} = I^2R$$

where *R* is the resistance of the part under consideration and *I* the current flowing in that part. The resistance should be that at running temperature.

Stray power loss cannot be accurately calculated by any simple data and is usually determined by experiment. In this article the author will give a simple and reasonably accurate means of finding the core loss in a series motor. It is necessary to know all the losses mentioned in order to find the efficiency of a motor or generator. Core-loss tests are made by the manufacturers on one machine for

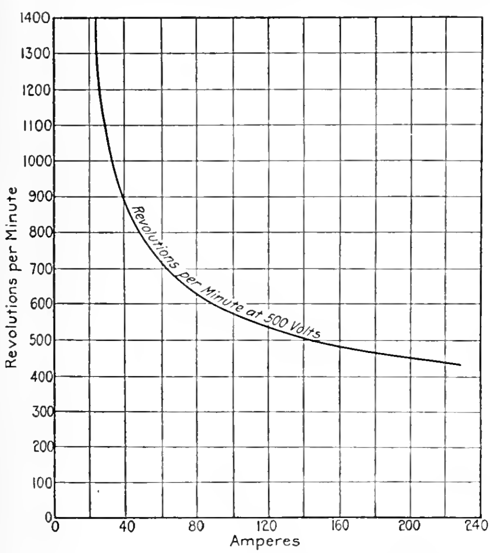


Fig. 1. Speed Curve for 500-Volt Series Motor

each type and class, and hold, with but slight variations, for all machines of the same size and design. While it is usually impractical to make these tests outside a laboratory, still it is interesting to know how they are carried out. Following is the method employed by one of the largest manufacturers of electrical machinery in this country:

The motor or generator under test is mounted on the test stand and is connected by means of a sleeve coupling to a similar motor which runs as a generator and furnishes the load. Holding the motor voltage constant, the load is varied from about 30 to 175 per cent. of normal, and the corresponding speeds are carefully observed.

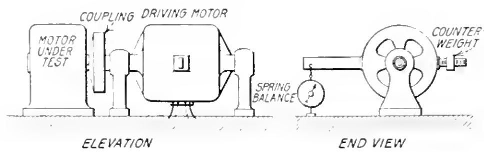


Fig. 2. Showing Driving Motor and Bearings which Allow Frame to Turn About Its Axis

From these data a speed curve is obtained having revolutions per minute as ordinates and current, or load, as abscissas; such a curve is shown in Fig. 1.

The motor is next disconnected from the position mentioned and is connected to a motor dynamometer, as shown in Fig. 2. The motor of the latter is mounted on ball bearings so that the frame is free to turn as well as the armature. A lever arm is attached to the side of the frame, and from this a spring-balance is suspended, the other end of the balance being fastened to the floor. This spring-balance furnishes the force necessary to keep the frame from revolving. The machine under test is then run as a separately excited generator operating at zero load.

About five speeds are selected from the speed curve, and runs are made at each, using five different field excitations for each speed. At the lower speeds the field current on the generator will, of course, have to be higher than at high speeds. Having decided upon the speeds and corresponding field excitations, the field of the motor under test is completely demagnetized by means of a reversing switch installed for that purpose, and the driving motor is started at the lowest speed decided upon. The set is now run until the reading upon the spring-balance is constant. This first reading takes care of all friction losses in the driving motor as well as the motor under test.

The maximum field current is now thrown on and, keeping the speed constant at the first value, the pull on the spring-balance is noted. The four other values of field current are applied consecutively and the corresponding spring-balance readings recorded. The fields are then demagnetized as before by momentarily reversing the field current and a second friction reading is taken, which should check exactly with the first. This process is simply repeated for the higher speeds and their correspondingly lower field currents.

The watts loss in the armature can now be calculated. The net pull on the spring-balance, that is, the reading with the field excited minus that with the demagnetized field, is a measure of the watts lost. The length of the arm from the spring-balance to the center line of the motor shaft can be measured, and the other values in the equation

$$Watts = \frac{2 \pi l n W}{33,000} \times 746$$

are known, where

l = Length of the lever arm in feet;

n = Revolutions per minute of the driving motor;

W = Net pull on the scales in pounds.

From the data thus obtained five curves may be drawn, one for each speed, having watts for ordinates and field current for abscissas. These should be drawn on the same curve sheet as was used for the speed curve; see Fig. 3.

The core-loss curve may now be readily drawn in. Suppose it is desired to find the point where the core-loss

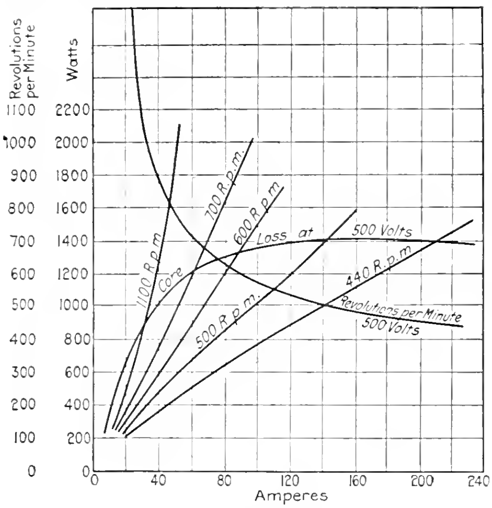


Fig. 3. Core-Loss and Speed Curves

curve crosses the 500-r.p.m. curve. Find the field current corresponding to 500 r.p.m. from the speed curve; this is about 140 amp. The point where this field current crosses the 500 r.p.m. curve will be one point on the core-loss curve.

A somewhat quicker way, but not as accurate, is to find the field current corresponding to a given speed and then run the motor under test at this speed and field excitation. The pull on the spring-balance is recorded as before and the watts lost calculated. This will give a point on the core-loss curve corresponding to the field current used; other points may be obtained in a similar manner.

The first method is the more accurate inasmuch as any error will quickly show in the core-loss curves taken at constant speed.

As will be seen, the core loss of a series motor varies greatly with load. With a shunt machine, on the other hand, it is practically constant irrespective of load.

The advantage of the method described lies in the fact that the electrical calculations are reduced to a minimum. It is not necessary to know the input to the driving motor or to know what losses there are in it.

The curves here shown are taken from a 50-hp. 500-volt G. E. railway motor.

JUST FOR FUN

As Usual, No Mystery When Found Out

On arriving at the plant in response to a distress call from the night man, I inquired what was wrong. He placed his hand gingerly on the low-pressure valve-chest cover and informed me it was hot. It was quite evident from the smell in the room that something was hot. He then told me that the engine had not been running evenly, but he could locate no other "trouble."

Upon examination I found the pedestal bearing hot and the bronze bearing gripping, causing the engine to slow down and then race. The oil drain-cock had been accidentally opened while cleaning the engine, and although the machine had been running over an hour, the so-called engineer had not discovered the lack of oil, but instead was looking for "something mysterious."—*F. E. Wood, Whitinsville, Mass.*

Absurdity Not Always Funny

I read with some amusement the letter by Mr. Newbury in the issue of Mar. 2, under the column headed "Just for Fun," wherein he refers to the blower salesman's remarks. While the statement was absurd, it does not sound quite so funny to one who has had the following experience.

A blower was sold, and the manufacturer was advised shortly afterward that the plant operator could not run the blower because it blew the gases out into the boiler room. Upon investigation he found that the man operating the plant insisted upon opening the blower valve to its full extent, regardless of the amount of air required. As the blower was installed with a fair margin of extra capacity, it was not ordinarily necessary to operate it at its full rate. Still, the fireman thought he ought by all means to do so, even if he spoiled the fire and filled the boiler room with gas. The main thing in his mind was to operate at full speed.

Is this experience any less funny than the other?—*T. L. Hoyt, New York City.*

As Good as Ever

In the palmy days of the Mississippi River shipping, the captain of one of the crack racing boats, the "Natchez," I think, was preparing to sail up the river from New Orleans, and finding that a rival boat was to sail about the same time, took occasion to impress upon his colored fireman the importance of having a good head of steam at starting time.

A few minutes before time to depart the captain strolled over in front of the boilers and was surprised to note that the steam gage showed exactly zero.

Naturally he wanted to know why in "hellenblazes" and several other things the fireman hadn't got up steam, to which the colored gentleman replied: "Dat's all right, Cap'n, dat thing's done been around once."

The above is a "wheeze" for which the writer can not vouch, on account of its not being true; still, it may interest such readers as have not heard it before. But if the steam gages had the stop pin taken out or were made so they *could* go around the second time we would be willing to believe the story, judging from some known incidents.—*L. A. States, Gastonia, N. C.*

Horsepower Constants for G. E. Type F Steam-Flow Meter

By Hubert E. Collins

SYNOPSIS—This article contains horsepower tables to be used with the G. E. steam-flow meter with several sizes of steam pipes. The tables are not corrected for moisture or for any other inner mechanism than a No. 6.

Chart readings taken from the G. E. Type F steam-flow meter must be computed by the method laid down in the instruction book No. Y 328, Sept., 1913, which also contains diagram No. 11, with the formula as shown herewith.

Meters not having the integrating attachment require considerable computation to figure the daily output registered. In order that the average of a day's run can be arrived at, the chart reading should be figured at least every half-hour. To get the rate of flow at any half-hour period requires four computations. If the factory has a number of meters, the work is considerable.

The accompanying tables are figured for a No. 6 inner mechanism General Electric Type F steam-flow meter for which the constant K_{cp} on the chart is 1.000. To use the tables with any other inner mechanism, multiply the reading from the table by the constant K_{cp} for that one.

These tables do not take into consideration the moisture of the steam or superheat, and any reading from them must be corrected for one of these. This means that it is necessary to multiply by constant K_1.

To illustrate the calculation of one of these figures in the table, let us figure the rated boiler horsepower passing through a 12-in. pipe at 100-lb. pressure, the chart reading being 2.

Then

$$K_2 = 0.835;$$
$$K_3 = 15{,}750;$$
$$K_{cp} = 1.000.$$

$15{,}750 \times 0.835 = 13{,}151$ *lb. of steam per hour rate*

$$\frac{13{,}151}{30} = 438 \text{ boiler horsepower}$$

TABLE 1. HORSEPOWER CONSTANTS FOR "TYPE F." G.E. STEAM-FLOW METER

Gage Pressure	Pipe Sizes 12-In.	10-In.	8-In.	6-In.	4-In	3-In.
20	241	161	95	53	21	12.2
25	260	173	102	57	23	13.2
30	275	183	108	61	24	14
35	288	192	113	64	25	14 6
40	301	201	118	67	25	15.3
45	315	210	124	70	28	16
50	328	218	129	72	29	16.6
55	341	227	134	75	30	17.3
60	354	236	139	78	31	18
65	364	243	143	81	32	18.5
70	375	250	147	83	33	19
75	385	257	151	85	34	19 6
80	396	264	156	88	35	20
85	406	271	160	90	36	20.6
90	417	278	164	92	37	21.2
95	427	285	168	95	38	21 7
100	438	292	172	97	38.9	22.2
105	446	297	175	99	39.6	22.6
110	456	304	179	101	40	23.2
115	464	309	182	103	41	23.6
120	472	315	186	105	42	24
125	483	322	190	107	42.8	24.5
130	490	327	193	109	43 6	24.9
135	498	332	196	110	44.3	25.3
140	506	337	199	112	45	25.7
145	514	343	202	114	45.7	26.1
150	525	350	206	116	46.6	26.6

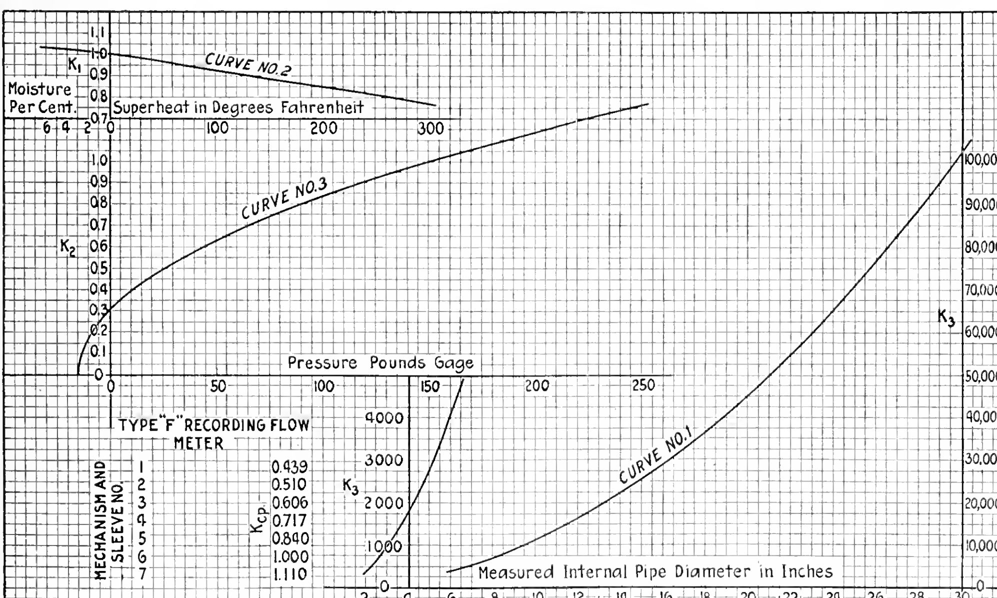


Diagram No. 11, for Use with Type F Recording Steam-Flow Meter

For the purpose of calculating the tables the following constants are taken from the chart:

K_3

		Constants
2-in. pipe	= $11\frac{3}{4}$-in. internal diameter	= 15,750
0-in. pipe	= $9\frac{3}{4}$-in. internal diameter	= 10,500
8-in. pipe	= $7\frac{1}{2}$-in. internal diameter	= 6,200
6-in. pipe	= $5\frac{1}{2}$-in. internal diameter	= 3,500
4-in pipe	= $3\frac{3}{8}$-in. internal diameter	= 1,400
3-in. pipe	= $2\frac{1}{4}$-in. internal diameter	= 800

K_2

Gage Pressure	Constants	Gage Pressure	Constants	Gage Pressure	Constants
20	= 0.46	65	= 0.695	110	= 0.87
25	= 0.495	70	= 0.715	115	= 0.885
30	= 0.525	75	= 0.735	120	= 0.9
35	= 0.55	80	= 0.755	125	= 0.92
40	= 0.575	85	= 0.775	130	= 0.935
45	= 0.6	90	= 0.795	135	= 0.95
50	= 0.625	95	= 0.815	140	= 0.965
55	= 0.65	100	= 0.835	145	= 0.98
60	= 0.675	105	= 0.85	150	= 1.000

TABLE 2. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 12 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	241	362	482	602	723	843	964	1084	1205	1325	1446	1566	1687	1807	1928	2048	2169	2289	2410
25	260	390	520	650	780	910	1040	1170	1300	1430	1560	1690	1820	1950	2080	2210	2340	2470	2600
30	275	412	550	687	825	962	1100	1237	1375	1512	1650	1787	1925	2062	2200	2337	2475	2612	2750
35	288	432	576	720	864	1008	1152	1296	1440	1584	1728	1872	2016	2160	2304	2448	2592	2736	2880
40	301	451	602	752	903	1053	1204	1354	1505	1655	1806	1956	2107	2257	2408	2558	2709	2859	3010
45	315	472	630	787	945	1102	1260	1417	1575	1732	1890	2047	2205	2362	2520	2677	2835	2992	3150
50	328	492	656	820	984	1148	1312	1476	1640	1804	1968	2132	2296	2460	2624	2788	2952	3116	3280
55	341	511	682	852	1023	1193	1364	1534	1705	1875	2046	2216	2387	2557	2728	2898	3069	3239	3410
60	354	531	708	885	1062	1239	1416	1593	1770	1947	2124	2301	2478	2655	2832	3009	3186	3363	3540
65	364	546	728	910	1092	1274	1456	1638	1820	2002	2184	2366	2548	2730	2912	3094	3276	3458	3640
70	375	562	750	937	1125	1312	1500	1687	1875	2062	2250	2437	2625	2812	3000	3187	3375	3562	3750
75	385	577	770	962	1155	1347	1540	1732	1925	2117	2310	2502	2695	2887	3080	3272	3465	3657	3850
80	396	594	792	990	1188	1386	1584	1782	1980	2178	2376	2574	2772	2970	3168	3366	3564	3762	3960
85	406	609	812	1015	1218	1421	1624	1827	2030	2233	2436	2639	2842	3045	3248	3451	3654	3857	4060
90	417	625	834	1042	1251	1459	1668	1876	2085	2293	2502	2710	2919	3127	3336	3544	3753	3961	4170
95	427	640	854	1067	1281	1494	1708	1921	2135	2348	2562	2775	2989	3202	3416	3629	3843	4056	4270
100	438	657	876	1095	1314	1533	1752	1971	2190	2409	2628	2847	3066	3285	3504	3723	3942	4161	4380
105	446	669	892	1115	1338	1561	1784	2007	2230	2453	2676	2899	3122	3345	3568	3791	4014	4237	4460
110	456	684	912	1140	1368	1596	1824	2052	2280	2508	2736	2964	3192	3420	3648	3876	4104	4332	4560
115	464	696	928	1160	1392	1624	1856	2088	2320	2552	2784	3016	3248	3480	3712	3944	4176	4408	4640
120	472	708	944	1180	1416	1652	1888	2124	2360	2596	2832	3068	3304	3540	3776	4012	4248	4484	4720
125	483	724	966	1207	1449	1690	1932	2173	2415	2656	2898	3139	3381	3622	3864	4105	4347	4588	4830
130	490	735	980	1225	1470	1715	1960	2205	2450	2695	2940	3185	3430	3675	3920	4165	4410	4655	4900
135	498	747	996	1245	1494	1743	1992	2241	2490	2739	2988	3237	3486	3735	3984	4233	4482	4731	4980
140	506	759	1012	1265	1518	1771	2024	2277	2530	2783	3036	3289	3542	3795	4048	4301	4554	4807	5060
145	514	771	1028	1285	1542	1799	2056	2313	2570	2827	3084	3341	3598	3855	4112	4369	4626	4883	5140
150	525	787	1050	1312	1575	1837	2100	2362	2625	2887	3150	3412	3675	3937	4200	4462	4725	4987	5250

TABLE 3. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 10 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	161	241	322	402	483	563	644	724	805	885	966	1046	1127	1207	1288	1368	1449	1529	1610
25	173	259	346	432	519	605	692	778	865	951	1038	1124	1211	1297	1384	1470	1557	1643	1730
30	183	274	366	457	549	640	732	823	915	1006	1098	1189	1281	1372	1464	1555	1647	1738	1830
35	192	288	384	480	576	672	768	864	960	1056	1152	1248	1344	1440	1536	1632	1728	1824	1920
40	201	301	402	502	603	703	804	904	1005	1105	1206	1306	1407	1507	1608	1708	1809	1909	2010
45	210	315	420	525	630	735	840	945	1050	1155	1260	1365	1470	1575	1680	1785	1890	1995	2100
50	218	327	436	545	654	763	872	981	1090	1199	1308	1417	1526	1635	1744	1853	1962	2071	2180
55	227	340	454	567	681	794	908	1021	1135	1248	1362	1475	1589	1702	1816	1929	2043	2156	2270
60	236	354	472	590	708	826	944	1062	1180	1298	1416	1534	1652	1770	1888	2006	2124	2242	2360
65	243	364	486	607	729	850	972	1093	1215	1336	1458	1579	1701	1822	1944	2065	2187	2308	2430
70	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125	2250	2375	2500
75	257	385	514	642	771	899	1028	1156	1285	1413	1542	1670	1799	1927	2056	2184	2313	2461	2570
80	264	396	528	660	792	924	1056	1188	1320	1452	1584	1716	1848	1980	2112	2244	2376	2508	2640
85	271	406	542	677	813	948	1084	1219	1355	1490	1626	1761	1897	2032	2168	2303	2439	2574	2710
90	278	417	556	695	834	973	1112	1251	1390	1529	1668	1807	1946	2085	2224	2363	2502	2641	2780
95	285	427	570	712	855	997	1140	1282	1425	1567	1710	1852	1995	2137	2280	2422	2565	2707	2850
100	292	438	584	730	876	1022	1168	1314	1460	1606	1752	1898	2044	2190	2336	2482	2628	2774	2920
105	297	445	594	742	891	1039	1188	1336	1485	1633	1782	1930	2079	2227	2376	2524	2673	2821	2970
110	304	456	608	760	912	1064	1216	1368	1520	1672	1824	1976	2128	2280	2432	2584	2736	2888	3040
115	309	463	618	772	927	1081	1236	1390	1545	1699	1854	2008	2163	2317	2472	2626	2781	2935	3090
120	315	472	630	787	945	1102	1260	1417	1575	1732	1890	2047	2205	2362	2520	2677	2835	2992	3150
125	322	483	644	805	966	1127	1288	1449	1610	1771	1932	2093	2254	2415	2576	2737	2898	3059	3220
130	327	490	654	817	981	1144	1308	1471	1635	1798	1962	2125	2289	2452	2616	2779	2943	3106	3270
135	332	498	664	830	996	1162	1328	1494	1660	1826	1992	2158	2324	2490	2656	2822	2988	3154	3320
140	337	505	674	842	1011	1179	1348	1516	1685	1853	2022	2190	2359	2527	2696	2864	3033	3201	3370
145	343	514	686	857	1029	1200	1372	1543	1715	1886	2058	2229	2401	2572	2744	2915	3087	3258	3430
150	350	525	700	875	1050	1225	1400	1575	1750	1925	2100	2275	2450	2625	2800	2975	3150	3325	3500

TABLE 4. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 8 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	95	142	190	237	285	332	380	427	475	522	570	617	665	712	760	807	855	902	950
25	102	153	204	255	306	357	408	459	510	561	612	663	714	765	816	867	918	969	1020
30	108	162	216	270	324	378	432	486	540	594	648	702	756	810	864	918	972	1026	1080
35	113	169	226	282	339	395	452	508	565	621	678	734	791	847	904	960	1017	1073	1130
40	118	177	236	295	354	413	472	531	590	649	708	767	826	885	944	1003	1062	1121	1180
45	124	186	248	310	372	434	496	558	620	682	744	806	868	930	992	1054	1116	1178	1240
50	129	193	258	322	387	451	516	580	645	709	774	838	903	967	1032	1096	1161	1225	1290
55	134	201	268	335	402	469	536	603	670	737	804	871	938	1005	1072	1139	1206	1273	1340
60	139	208	278	347	417	486	556	625	695	764	834	903	973	1042	1112	1181	1251	1320	1390
65	143	214	286	357	429	500	572	643	715	786	858	929	1001	1072	1144	1215	1287	1358	1430
70	147	220	294	367	441	514	588	661	735	808	882	955	1029	1102	1176	1249	1323	1396	1470
75	151	226	302	377	453	528	604	679	755	830	906	981	1057	1132	1208	1283	1359	1434	1510
80	156	234	312	390	468	546	624	702	780	858	936	1014	1092	1170	1248	1326	1404	1482	1560
85	160	240	320	400	480	560	640	720	800	880	960	1040	1120	1200	1280	1360	1440	1520	1600
90	164	246	328	410	492	574	656	738	820	902	984	1066	1148	1230	1312	1394	1476	1558	1640
95	168	252	336	420	504	588	672	756	840	924	1008	1092	1176	1260	1344	1428	1512	1596	1680
100	172	258	344	430	516	602	688	774	860	946	1032	1118	1204	1290	1376	1462	1548	1634	1720
105	175	262	350	437	525	612	700	787	875	962	1050	1137	1225	1312	1400	1487	1575	1662	1750
110	179	268	358	447	537	626	716	805	895	984	1074	1163	1253	1342	1432	1521	1611	1700	1790
115	182	273	364	455	546	637	728	819	910	1001	1092	1183	1274	1365	1456	1547	1638	1729	1820
120	186	279	372	465	558	651	744	837	930	1023	1116	1209	1302	1395	1488	1581	1674	1767	1860
125	190	285	380	475	570	665	760	855	950	1045	1140	1235	1330	1425	1520	1615	1710	1805	1900
130	193	289	386	482	579	675	772	868	965	1061	1158	1254	1351	1447	1544	1640	1737	1833	1930
135	196	294	392	490	588	686	784	882	980	1078	1176	1274	1372	1470	1568	1666	1764	1862	1960
140	199	298	398	497	597	696	796	895	995	1094	1194	1293	1393	1492	1592	1691	1791	1890	1990
145	202	303	404	505	606	707	808	909	1010	1111	1212	1313	1414	1515	1616	1717	1818	1919	2020
150	206	309	412	515	618	721	824	927	1030	1133	1236	1339	1442	1545	1648	1751	1854	1957	2060

With these constants table No. 1 is figured. This table gives the horsepower for the given pipe sizes and steam pressures for a reading of 1 on the meter chart. When using this table, multiply the chart reading by the constant corresponding to the pipe sizes and gage pressure. Then correct for moisture or superheat. If another inner mechanism than a No. 6 is used, correct for that, as already stated.

The integrating attachment to one of these meters does away with the necessity of calculating the steam flow at stated periods and averaging the result, or adding them to get the total. The device gives the total chart reading, which is multiplied by the result of the calculations given with Diagram No. 11.

With the integrating device the following formula is given for Type F meter with nozzle plug:

$$\textit{Total flow in lb.} = \frac{\textit{net dial reading} \times 4.7 \times K_1 \times K_2 \times K_3 \times K_4 \times K_{cp}}{\textit{revolutions of chart in 24 hr.}}$$

TABLE 5. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 6 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	53	79	106	132	159	185	212	238	265	291	318	344	371	397	424	450	477	503	530
25	57	85	114	142	171	199	228	256	285	313	342	370	399	427	456	484	513	541	570
30	61	91	122	152	183	213	244	274	305	335	366	396	427	457	488	518	549	579	610
35	64	96	128	160	192	224	256	288	320	352	384	416	448	480	512	544	576	608	640
40	67	100	134	167	201	234	268	301	335	368	402	435	469	502	536	569	603	636	670
45	70	105	140	175	210	245	280	315	350	385	420	455	490	525	560	595	630	665	700
50	72	108	144	180	216	252	288	324	360	396	432	468	504	540	576	612	648	684	720
55	75	112	150	187	225	262	300	337	375	412	450	487	525	562	600	637	675	712	750
60	78	117	156	195	234	273	312	351	390	429	468	507	546	585	624	663	702	741	780
65	81	121	162	202	243	283	324	364	405	445	486	526	567	607	648	688	729	769	810
70	83	124	166	207	249	290	332	373	415	456	498	539	581	622	664	705	747	788	830
75	85	127	170	212	255	297	340	382	425	467	510	552	595	637	680	722	765	807	850
80	88	132	176	220	264	308	352	396	440	484	528	572	616	660	704	748	792	836	880
85	90	135	180	225	270	315	360	405	450	495	540	585	630	675	720	765	810	855	900
90	92	138	184	230	276	322	368	414	460	506	552	598	644	690	736	782	828	874	920
95	95	142	190	237	285	332	380	427	475	522	570	617	665	712	760	807	855	902	950
100	97	145	194	242	291	339	388	436	485	533	582	630	679	727	776	824	873	921	970
105	99	148	198	247	297	346	396	445	495	544	594	643	693	742	792	841	891	940	990
110	101	151	202	252	303	353	404	454	505	555	606	656	707	757	808	858	909	959	1010
115	103	154	206	257	309	360	412	463	515	566	618	669	721	772	824	875	927	978	1030
120	105	157	210	262	315	367	420	472	525	577	630	682	735	787	840	892	945	997	1050
125	107	160	214	267	321	374	428	481	535	588	642	695	749	802	856	909	963	1016	1070
130	109	163	218	272	327	381	436	490	545	599	654	708	763	817	872	926	981	1035	1090
135	110	165	220	275	330	385	440	495	550	605	660	715	770	825	880	935	990	1045	1100
140	112	168	224	280	336	392	448	504	560	616	672	728	784	840	896	952	1008	1064	1120
145	114	171	228	285	342	399	456	513	570	627	684	741	798	855	912	969	1026	1083	1140
150	116	174	232	290	348	406	464	522	580	638	696	754	812	870	928	986	1044	1102	1160

TABLE 6. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 4 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	21	31	42	52	63	73	84	94	105	115	126	136	147	157	168	178	189	199	210
25	23	34	46	57	69	80	92	103	115	126	138	149	161	172	184	195	207	218	230
30	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
35	25	37	50	62	75	87	100	112	125	137	150	162	175	187	200	212	225	237	250
40	26	39	52	65	78	91	104	117	130	143	156	169	182	195	208	221	234	247	260
45	28	42	56	70	84	98	112	126	140	154	168	182	196	210	224	238	252	266	280
50	29	43	58	72	87	101	116	130	145	159	174	188	203	217	232	246	261	275	290
55	30	45	60	75	90	105	120	135	150	165	180	195	210	225	240	255	270	285	300
60	31	46	62	77	93	108	124	139	155	170	186	201	217	232	248	263	279	294	310
65	32	48	64	80	96	112	128	144	160	176	192	208	224	240	256	272	288	304	320
70	33	49	66	82	99	115	132	148	165	181	198	214	231	247	264	280	297	313	330
75	34	51	68	85	102	119	136	153	170	187	204	221	238	255	272	289	306	323	340
80	35	52	70	87	105	122	140	157	175	192	210	227	245	262	280	297	315	332	350
85	36	54	72	90	108	126	144	162	180	198	216	234	252	270	288	306	324	342	360
90	37	55	74	92	111	129	148	166	185	203	222	240	259	277	296	314	333	351	370
95	38	57	76	95	114	133	152	171	190	209	228	247	266	285	304	323	342	361	380
100	38.9	58.3	77.8	97.2	116.7	136.1	155.6	175	194.5	213.9	233.4	252.8	272.3	291.7	311.2	330.6	350.1	369.5	389
105	39.6	59.4	79.2	99	118.8	138.6	158.4	178.2	198	217.8	237.6	257.4	277.2	297	316.8	336.6	356.4	376.2	396
110	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	310	360	380	400
115	41	61	82	102	123	143	164	184	205	225	246	266	287	307	328	348	369	389	410
120	42	63	84	105	126	147	168	189	210	231	252	273	294	315	336	357	378	399	420
125	42.8	64.2	85.6	107	128.4	149.8	171.2	192.6	214	235.4	256.8	278.2	299.6	321	342.4	363.8	385.2	406.6	428
130	43.6	65.4	87.2	109	130.8	152.6	174.4	196.2	218	239.8	261.6	283.4	305.2	327	348.8	370.6	392.4	414.2	436
135	44.3	66.4	88.6	110.7	132.9	155	177.2	199.3	221.5	243.6	265.8	287.9	310.1	332.2	354.4	376.5	398.7	420.8	443
140	45	67	90	112	135	157	180	202	225	247	270	292	315	337	360	382	405	427	450
145	45.7	68.5	91.4	114.2	137.1	159.9	182.8	205.6	228.5	251.3	274.2	297	319.9	342.7	365.6	388.4	411.3	434.1	457
150	46.6	69.9	93.2	116.5	139.8	163.1	186.4	209.7	233	256.3	279.6	302.9	326.2	349.5	372.8	396.1	419.4	442.7	466

TABLE 7. HORSEPOWER PER HOUR TRANSMITTED

Pipe Diameter = 3 In.

Chart Reading

Pressure	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
20	12.2	18.3	24.4	30.5	36.6	42.7	48.8	54.9	61	67.1	73.2	79.3	85.4	91.5	97.6	103.7	109.8	115.9	122
25	13.2	19.8	26.4	33	39.6	46.2	52.8	59.4	66	72.6	79.2	85.8	92.4	99	105.6	112.2	118.8	125.4	132
30	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140
35	14.6	21.9	29.2	36.5	43.8	51.1	58.4	65.7	73	80.3	87.6	94.9	102.2	109.5	116.8	124.1	131.4	138.7	146
40	15.3	22.9	30.6	38.2	45.9	53.5	61.2	68.8	76.5	84.1	91.8	99.4	107.1	114.7	122.4	130	137.7	145.3	153
45	16	24	32	40	48	56	64	72	80	88	96	104	112	120	128	136	144	152	160
50	16.6	24.9	33.2	41.5	49.8	58.1	66.4	74.7	83	91.3	99.6	107.9	116.2	124.5	132.8	141.1	149.4	157.7	166
55	17.3	25.9	34.6	43.2	51.9	60.5	69.2	77.8	86.5	95.1	103.8	112.4	121.1	129.7	138.4	147	155.7	164.3	173
60	18	27	36	45	54	63	72	81	90	99	108	117	126	135	144	153	162	171	180
65	18.5	27.7	37	46.2	55.5	64.7	74	83.2	92.5	101.7	111	120.2	129.5	138.7	148	157.2	166.5	175.7	185
70	19	28.5	38	47.5	57	66.5	76	85.5	95	104.5	114	123.5	133	142.5	152	161.5	171	180.5	190
75	19.6	29.4	39.2	49	58.8	68.6	78.4	88.2	98	107.8	117.6	127.4	137.2	147	156.8	166.6	176.4	186.2	196
80	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
85	20.6	30.9	41.2	51.5	61.8	72.1	82.4	92.7	103	113.3	123.6	133.9	144.2	154.5	164.8	175.1	185.4	195.7	206
90	21.2	31.8	42.4	53	63.6	74.2	84.8	95.4	106	116.6	127.2	137.8	148.4	159	169.6	180.2	190.8	201.4	212
95	21.7	32.5	43.4	54.2	65.1	75.9	86.8	97.6	108.5	119.3	130.2	141	151.9	162.7	173.6	184.4	195.3	206.1	217
100	22.2	33.3	44.4	55.5	66.6	77.7	88.8	99.9	111	122.1	133.2	144.3	155.4	166.5	177.6	188.7	199.8	210.9	222
105	22.6	33.9	45.2	56.5	67.8	79.1	90.4	101.7	113	124.3	135.6	146.9	158.2	169.5	180.8	192.1	203.4	214.7	226
110	23.2	34.8	46.4	58	69.6	81.2	92.8	104.4	116	127.6	139.2	150.8	162.4	174	185.6	197.2	208.8	220.4	232
115	23.6	35.4	47.2	59	70.8	82.6	94.4	106.2	118	129.8	141.6	153.4	165.2	177	188.8	200.6	212.4	224.2	236
120	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240
125	24.5	36.7	49	61.2	73.5	85.7	98	110.2	122.5	134.7	147	159.2	171.5	183.7	196	208.2	220.5	232.7	245
130	24.9	37.3	49.8	62.2	74.7	87.1	99.6	112	124.5	136.9	149.4	161.8	174.3	186.7	199.2	211.6	224.1	236.5	249
135	25.3	37.9	50.6	63.2	75.9	88.5	101.2	113.8	126.5	139.1	151.8	164.4	177.1	189.7	202.4	215	227.7	240.3	253
140	25.7	38.5	51.4	64.2	77.1	89.9	102.8	115.6	128.5	141.3	154.2	167	179.9	192.7	205.6	218.4	231.3	244.1	257
145	26.1	39.1	52.2	65.2	78.3	91.3	104.4	117.4	130.5	143.5	156.6	169.6	182.7	195.7	208.8	221.8	234.9	247.9	261
150	26.6	39.9	53.2	66.5	79.8	93.1	106.4	119.7	133	146.3	159.6	172.9	186.2	199.5	212.8	226.1	239.4	252.7	266

The numeral 4.7 stands for the integrating dial constant which is given on the nameplate.

To use these tables the formula is as follows:

$$\textit{Total horsepower} = \frac{\textit{net dial reading} \times \textit{constant} \times \textit{horsepower from Table 1}}{\textit{revolutions of chart in 24 hr.}}$$

To change to number of pounds of steam, multiply the above by 30.

If other than No. 6 inner mechanism is used, multiply the above by the constant given in Diagram 11 for the proper mechanism.

Correct for moisture or superheat.

For example, let us assume the following: The steam-pipe diameter is 12 in.; the average steam pressure at 100 lb. equals 438 hp. (Table 1); the integrating-dial reading for 24 hr. is 30; the dial constant is 4.7; and the reading of the meter chart in revolutions is 1. Then

$$\frac{30 \times 4.7 \times 438}{1} = 61{,}758 \textit{ total horsepower}$$

Where the integrating device is not in use, the Tables 2, 3, 4, 5, 6 and 7 are of especial use. With these the horsepower for any chart reading and given pressure can be read direct; each table is for a given pipe size.

Converter Station of Aluminum Company of America

SYNOPSIS—The equipment includes nine 2500-kw. rotary converters, outdoor transformers and high-tension switches and special control and protective apparatus.

The installation of nine 2500-kw. 60-cycle rotary converters at the Little Tennessee Plant of the Aluminum Company of America at Maryville, Tenn., in addition to constituting one of the largest 60-cycle rotary-converter installations in the world, presents a number of interesting features in the arrangement of the controlling and protective equipment. Energy is brought to the station by the Tennessee Power Co. over a single-circuit transmission line 70 miles in length, consisting of 400,000-circ.mil stranded aluminum cables, carried on steel towers 55 ft. in height, the lines being hung from suspension insulators. Temporarily, a transmission voltage of 66,000 is used, which later will be boosted to 110,000 volts.

Two banks of three 3650-kv.-a. 110,000/66,000-volt outdoor-type single-phase transformers are used to step down to the converter voltage, four six-phase machines

Fig. 1. Interior View of Station, Showing Converters and Control Panels

operating from independent secondaries on each bank, with provision for operating one spare unit from any set of secondaries of either bank. Automatic overload protection is provided by three-pole outdoor oil circuit-breakers equipped with outdoor condenser-type terminals and ring-type current transformers. The breakers are solenoid operated, and are controlled from the control desk located in the station. The breakers are isolated from the transmission line by means of three-pole outdoor disconnecting switches which are mechanically controlled by a handle installed in the station. One of these switches is shown in Fig. 2 between the supports of the transmission tower. The outdoor lightning arrester of the electrolytic type, shown at the left, provides protection against lightning.

The low-tension leads from the transformers are carried directly through the station wall and the six-phase connections are made beneath the floor. The aluminum-strap bus arrangement shown along the right-hand station wall in Fig. 1 provides the necessary connections for transferring the spare converter to any set of secondaries of either bank of step-down transformers.

The converters are ordinarily started from the 500-volt direct-current side, although two are arranged so that alternating-current starting motors may be used. Owing to the size of the machines and their large overload capacity, the switching equipment for both the alternating- and the direct-current ends is somewhat unusual in character. For the control of the alternating-current ends of the converters, 2500-amp., three-pole, solenoid-operated automatic carbon circuit-breakers are used, and for the direct-current ends the control consists of two 5000-amp., single-pole, solenoid-operated automatic carbon circuit-breakers for each machine. The alternating- and the direct-current panels are located adjacent to each ma-

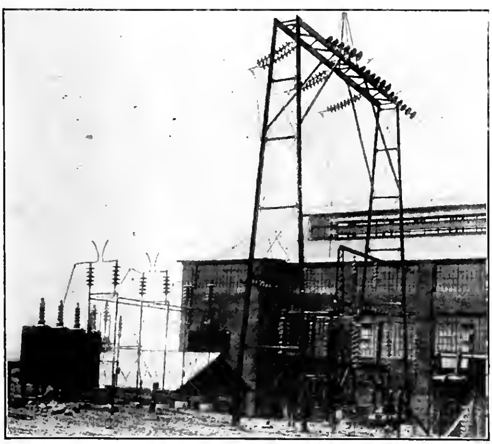


Fig. 2. Outdoor Switches and Lightning Arresters

chine, thus reducing to a minimum the length of the main connections. Low-voltage protection is provided on the alternating-current panels, and protection against reversal of direct current is secured by reverse-current relays.

The output of the converters, which is used in the manufacture of aluminum, is distributed through a 20,000-amp. single-pole solenoid-operated automatic carbon circuit-breaker, and two 10,000-amp. single-pole solenoid-operated automatic carbon circuit-breakers, mounted directly against the left-hand wall; see Fig. 1. The panels for the control of the direct-current ends are also on this side.

The details of the brush construction of the 20,000-amp. breaker are shown in Fig. 3. The main brush consists of six unit brushes of laminated copper so spaced as to secure the benefit of maximum ventilating effect.

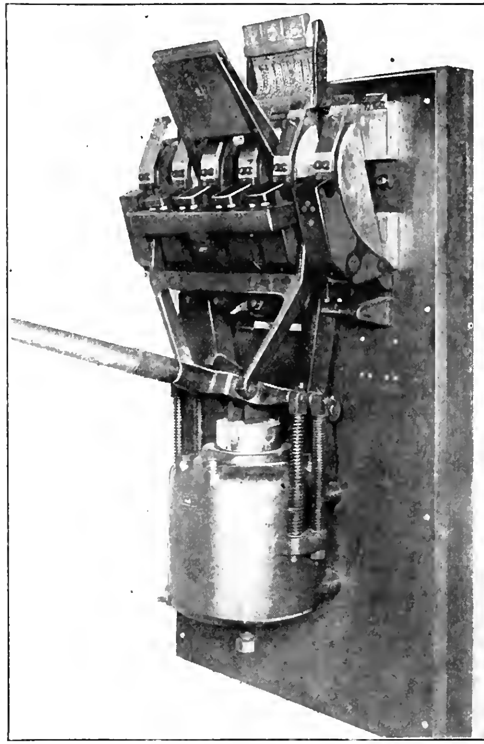


Fig. 3. 20,000-Amp. Circuit-Breaker

Auxiliary arc-interrupting contacts are located above the main brush and on the lower portion of the carbon contacts, which make the final break. Laminated studs are used for all breakers, and a single solenoid is used for operating each breaker, regardless of the number of poles, making possible a very simple and direct-acting operating mechanism.

The metering and controlling equipment for the alternating- and the direct-current sides of the converters, as well as for the high-tension side of the step-down transformers, is installed upon the control desk located in the balcony.

Current for operating the solenoids of the switching equipment and for the station lighting is provided by a motor-generator set consisting of a 60-kv.-a., 125-250 volt, three-phase generator driven by a 500-volt direct-current motor.

The electrical equipment for the station was manufactured by the Westinghouse Electric & Manufacturing Co. under the direction of William Hoopes, electrical engineer of the Aluminum Company of America.

Inconspicuous Losses in Refrigerating Plants

By Peter Neff

SYNOPSIS—You can see steam leaks and smell ammonia leaks, but you can neither see nor smell those heat losses by transmission through the walls that confine the heat units. The article suggests how these leaks may mean considerable loss in a short time.

Anyone can see a steam leak or smell an ammonia leak and know that a loss is going on, but many are often unaware of those silent, unnoticeable losses that go on continually, due to heat transmission, and while these cannot be entirely prevented, they can and should be minimized.

A plant may have good cold water and an efficient ammonia condenser, making it possible to get the liquid ammonia away from the condenser at, we will say, a temperature of 60 deg. Then this ammonia is conveyed through pipes to a receiver, perhaps located in a hot engine room, with the result that the ammonia goes to the feed valve possibly nearer 80 than 60 deg.

What do these 20 deg. mean? Suppose the plant is of 100 tons' refrigerating capacity and is circulating about 40 lb. of ammonia per minute, these 20 deg. mean about 800 heat units per minute unnecessarily added to the load. Two hundred heat units per minute is equivalent to a ton of refrigeration per day, so that this loss amounts to approximately four tons of refrigeration per day. It may be argued that this is not much in a 100-ton plant. But the loss represents money. The greater part might be saved by spending a few dollars on insulation, at least covering the receiver.

See that the ammonia leaves the condenser at as near as possible the temperature of the water available and that it does not rise in temperature before reaching the feed valves.

This brings up the question of the use of thermometers about a refrigerating plant, a subject the writer will take up at some future time. Suffice it for now to say, one might as well try to run an electric plant efficiently without voltmeters or ammeters as to attempt to operate a refrigerating plant without thermometers.

The suction line leading to the compressor is much neglected; sometimes it bears evidence of an attempt at insulation, but the last state is often worse than the first. Most engineers know of the loss due to the exposed steam piping, but frequently do not apply this knowledge to the suction line.

To relate an instance of how this matter is sometimes viewed, the writer found in a plant, a 4-in. ammonia suction line running partly in close proximity to steam condensers and thence through the hottest part of the engine room before reaching the compressor; obviously this line had been put there intentionally. Upon inquiry, this statement was given in answer: "You heat the gas in the compressor, therefore it is desirable to heat it as much as possible beforehand and save work by the machine." An hour was spent in a vain attempt to convince the operator of his error, but he had only pity for me and my ignorence. Happily, such instances are rare.

Suppose the suction line offers 100 sq.ft. of exposed surface, and assume a heat transmission of 10 units per hour per degree difference. It is no uncommon thing to find the suction line exposed to a room temperature of 80 deg., while the ammonia gas leaving the place of evaporation is at zero.

We may fairly assume an average difference of 60 deg., or 60,000 heat units per hour, which is equivalent to five tons of refrigeration per day. This is not all, for while the refrigeration load has been increased, the capacity of the compressor has been cut down.

It is well known that refrigeration is accomplished primarily by the heat absorbed in changing the liquid ammonia into a gas and that this gas is at first in what is termed a saturated condition where a given volume has a maximum weight. It is also well known that if this gas be heated it will expand and the weight in a given volume will be reduced. As the compressor offers a constant volume for the reception of the gas, it follows that the greater the density of the gas, the greater will be the weight handled by the compressor. So it is obvious that it is desirable to get the gas to the compressor without superheating it.

We have supposed that superheating of the gas has taken place, owing to the exposed suction line, so that in reality there has been an attempt to cool the engine room or outdoors, wherever the suction line has been run, which was neither desired nor intended, but which has required an expenditure of energy that represents a money loss.

In the supposed case the 40 lb. of ammonia per minute, when in the form of a saturated gas at zero degrees, occupied approximately 367 cu.ft. If, now, this gas is raised in temperature to only 50 deg., we find that the gas that had formerly occupied the space of 367 cu.ft. will now occupy 416 cu.ft. If the compressor is to handle the same weight of ammonia, which it must do to produce the same amount of refrigeration, its speed must be increased 13½ per cent.

The plant may be, as far as visible observation can tell, working well, everything apparently in perfect order, not a leak of steam or ammonia and yet there may be some such losses going on.

While, perhaps, the increased number of revolutions does not, owing to the friction load, increase the horsepower proportionately, it nearly does so, and almost any engineer may calculate what this loss means in fuel cost.

The engineer who wants to build up a reputation and to make himself valuable to the concern which employs him will, in addition to keeping his plant free from those defects that are obvious to anyone, be on the lookout for those losses not apparent on the surface. It is this care that makes some men so much more successful than others.

There are many other losses going on, but the examples given illustrate the importance of looking into the heat-transmission losses

Tests on the Diagonal Strength of Boiler Plate

By J. W. F. Macdonald*

On Apr. 10 tensile tests were conducted at the Watertown (Mass.) Arsenal on 21 specimens of boiler plate. The object of the tests was to determine the minimum distance between rows at which the joint fails through the net section along the line of rivets in one row, rather than along the zigzag diagonal lines. The test specimens

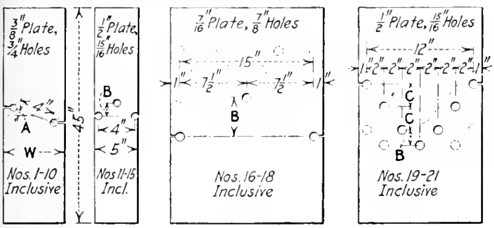


FIG. 1 FIG. 2 FIG. 3 FIG. 4

Specimens on Which Tests Were Made

were prepared by the International Engineering Works, Ltd., Framingham, Mass., from material furnished by the Lukens Iron & Steel Co., Coatesville, Penn. Following is the mill test report for the steel used:

Slab No.	9968 G	9968 J	9968 H
Physical properties—			
Width, in.	1.725	1.915	1.816
Thickness, in.	0.380	0.447	0.515
Area, sq.in.	0.655	0.856	0.935
Elastic limit—			
Lb. per sq.in.	36,660	38,090	36,160
Tensile strength—			
Lb. per sq.in.	59,680	59,340	57,760
Elongation—			
Per cent. in 8 in.	30.0	28.0	29.5
Reduction in area, per cent.	60.3	60.7	57.2
Chemical properties, per cent.—			
Carbon	0.17	0.17	0.18
Manganese	0.36	0.36	0.44
Sulphur	0.023	0.023	0.030
Phosphorus	0.018	0.018	0.012

The first ten specimens had a section 4 in. wide and 3/8 in. thick between hole centers. The lines through this section were placed at an angle *A* (see Fig. 1) to the line normal to stress, varying from 0 to 90 deg. in 10-deg. increments. The purpose of this series of ten was to obtain data for a curve giving the strength of the material for the different angles. From this curve the proportion of metal necessary along the diagonal lines could be found directly.

Specimens Nos. 11 to 21 inclusive were arranged with varying proportions between the net amount of material along the diagonal lines and that straight across between the two holes in the same line. Nos. 11, 12, 13, 14 and 15 (Fig. 2) had a 4-in. pitch and represented typical spacing in the inner rows of riveted joints. Nos. 16, 17 and 18 (Fig. 3) represented the rivet holes in the two outer rows of the ordinary type of quadruple butt joint with an outer pitch of 15 inches. In No. 16 there is actually less material along the diagonal lines between the two outer rows than there is directly between rivets in the outer row, a condition given no consideration in the rules for calculating such joints. Nos. 19, 20 and 21 (Fig. 4) represented the rivet holes inside the calking edge of the sawtooth type of quadruple butt joint with an outer pitch of 12 inches.

Where the same thickness of plate was used, test specimens were all cut from the same slab, in order to have conditions as uniform as possible. The actual results in the first ten specimens show remarkable uniformity, particularly with reference to the elastic limit indicated by the first scaling of the plate and drop of the beam. The results of tests made on these specimens follow:

No.	Angle A (See Fig. 1), Deg.	Width (W) Specimen, In.	Section Between Holes, Sq.In.	Elastic Limit in Lb. Total	Elastic Limit in Lb. Per Sq.In.	Ultimate Strength in Lb. Total	Ultimate Strength in Lb. Per Sq.In.	Relative Ultimate Strength Per Cent.
1	0	7	1.52	62,200	40,900	96,400	63,400	100
2	10	7	1.56	57,100	36,600	92,700	59,400	93.6
3	20	7	1.52	51,100	33,600	87,400	57,500	90.7
4	30	7	1.52	45,000	29,600	81,000	53,300	84.0
5	40	8	1.56	40,500	26,000	78,100	50,100	79.0
6	50	9	1.56	37,500	24,000	74,900	48,000	75.7
7	60	10	1.56	32,800	21,000	71,000	45,500	71.7
8	70	10	1.56	29,200	18,800	70,500	45,200	71.2
9	80	11	1.52	27,900	18,400	71,900	47,300	74.6
10	90	11	1.52	26,900	17,700	63,100	41,500	65.5

Curves Nos. 1 and 2 were plotted with the ultimate strength and elastic limits as ordinates and different angles as abscissas. These curves show that the ultimate strength decreased almost uniformly with the increased angle from direct tension to direct shear.

Specimen No. 11, in which the areas diagonally and straight across were equal, and No. 16, in which the latter was slightly greater, failed diagonally through the three holes, as was expected. Specimen No. 13 was stronger than would be indicated from the results found in the first ten specimens, the ultimate failure being straight across. With a riveted connection, where the holes were forced to retain their full width and the metal was prevented from flowing to the extent it did, as shown by the elongation of the holes along the line of stress and their contraction transversely, the results would probably

RESULTS OF TESTS ON SPECIMENS NOS. 11 TO 21 INCLUSIVE

No.	Section Normal to Stress: Width, In.	Section Normal to Stress: Thickness, In.	Section Normal to Stress: Area, Sq.In.	Diagonal Length, In.	Diagonal Section Area, Sq.In.	Diagonal in Per Cent. of Normal Section	Back Pitch (See Figs. 2-4) B, In.	Back Pitch C, In.	Elastic Limit in Lb. Total	Elastic Limit in Lb. Per Sq.In.	Ultimate Strength in Lb. Total	Ultimate Strength in Lb. Per Sq.In.	Efficiency of Section in Per Cent. Theoretical	Efficiency of Section in Per Cent. Actual
11	3.06	0.52	1.59	3.06	1.59	100	1.45	...	44,000	27,700	91,000	57,200	76.5	75.7
12	3.06	0.52	1.59	3.44	1.79	113	1.75	...	44,200	27,800	94,500	59,400	76.5	78.6
13	3.06	0.52	1.59	3.68	1.91	120	1.93	...	48,000	30,200	96,400	60,600	76.5	80.2
14	3.06	0.52	1.59	4.08	2.12	133	2.21	...	50,000	31,400	101,000	63,500	76.5	84.0
15	3.06	0.51	1.56	4.58	2.34	150	2.54	...	51,700	33,100	98,600	63,200	76.5	83.6
16	14.12	0.45	6.35	13.91	6.26	98	2.25	...	204,000	32,600	324,600	51,900	94.1	81.0
17	14.12	0.44	6.21	14.83	6.52	105	3.53	...	224,000	35,100	331,200	53,300	94.1	84.6
18	14.12	0.44	6.21	15.53	6.83	110	4.29	...	222,000	35,700	325,400	52,400	94.1	83.1
19	11.06	0.51	5.64	12.45	6.35	113	1.75	2.48	......	......	308,800	54,800	92.1	87.3
20	11.06	0.51	5.64	14.74	7.52	133	2.21	2.99	160,000	28,400	309,400	54,900	92.1	87.5
21	11.06	0.51	5.64	16.59	8.46	150	2.54	3.41	177,000	31,400	316,500	56,100	92.1	89.5

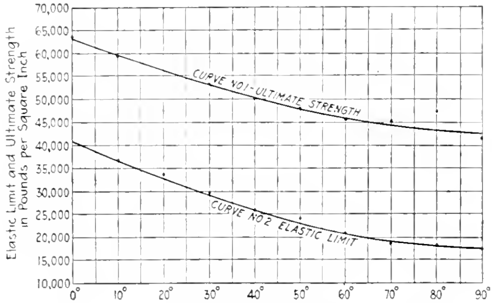
*Chief draftsman, International Engineering Works, Ltd., Framingham, Mass.

have agreed more closely with those obtained with the first ten specimens. Again, in these specimens the material was given more opportunity to stretch where its continuity was not wholly broken than if the stress was transferred from one plate to the other by rivets.

Specimen No. 13 was watched with especial interest, as the proportions conformed to those required as a minimum by the Canadian Rules, and also by the recent A. S. M. E. Code. Specimens Nos. 14 and 15 broke directly across, the third hole showing less deformation as the proportion of material increased diagonally.

It would be interesting in the line of further investigating of this condition to have the five specimens 11 to 15 inclusive prepared with exactly the same spacing of holes, only in the form of a butt joint with double strap, the double shearing strength of rivets being sufficient to insure a plate failure.

Specimen No. 16 broke through the three holes at an ultimate load far below the strength according to the methods of calculation used in the various boiler rules. This failure shows a rather astonishing condition in the ordinary type of quadruple butt joint. The condition has apparently existed for years without being given much consideration. In designing these joints the practice has been to find the weakest part by calculating eight possible methods of failure. Yet, what is the use of such calculations if the actual method of failure has not been considered at all? No matter if the ultimate strength by the real method of failure may be only very slightly below the calculated strength, so long as the condition exists at all, to be consistent a proper investigation should be made. It is a significant fact that this type of joint is not recognized by the various Canadian Rules, which we believe are patterned after the Code of the British Board of Trade.



Results Obtained with First Ten Specimens

Another feature noted in these tests was that in several of the samples which failed straight across the elastic limit indicated by the scaling of the plate was first shown along the diagonal lines, which under the conditions would perhaps be the proper criterion for judging the weakest section.

Another important point to be noted was that in the narrow specimens Nos. 12, 13, 14 and 15, with a 4-in. pitch, the ultimate strength came fully up to that which might be expected from the mill-test report, but as the specimens grew wider they fell far below. In specimens Nos. 19, 20 and 21, the calculated strength as compared with the solid plate should be 92.1 per cent., but actually was only 87.3 per cent., 87.5 per cent. and 89.5 per cent.; and in specimens Nos. 16, 17 and 18, where the strength should be 94.1 per cent. of the solid plate, it actually was only 81.0, 84.6 and 83.1 per cent. These results bear out exactly the statement made with reference to wide pitches by James E. Howard in his paper read last December before the Society of Naval Architects and Marine Engineers.

In this question of the proper back pitch, or distance between rows, the design should have some excess strength in favor of the material diagonally and not be merely a balance. Really, this part of the proportioning of any joint is a feature of the design preliminary to the proper calculation by the usual methods. In considering the different possible methods of failure, if no direct calculations are made for the strength diagonally, the proportions should be such that there is no possibility of the joint failing in that manner; or in other words, whatever the method of failure may be, it should be among those for which direct calculations are made.

These tests, which will perhaps open the way for further research along this line, tend to arouse suspicions as to our high efficiencies. If the 94 per cent. and more of the strength of the solid plate are not dependable figures, we may again be falling back on our old friend the "factor of safety" to make up the difference between actual and assumed conditions.

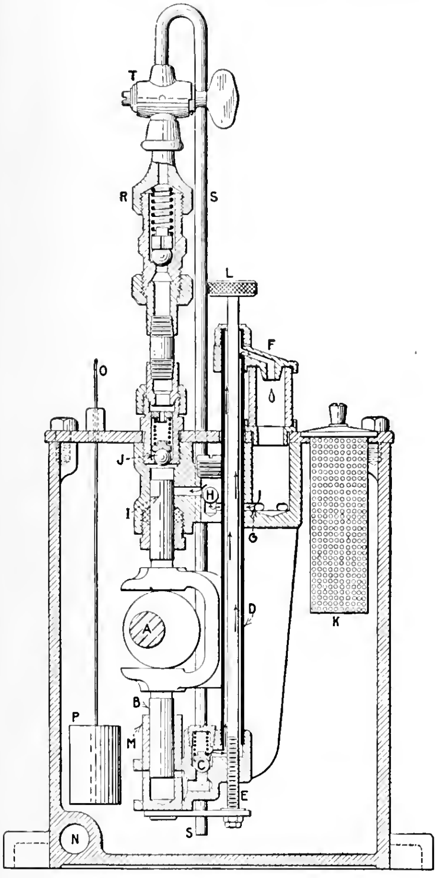
Phenix Oil and Graphite Cylinder Lubricator

Quite recently the Richardson-Phenix Co., of Milwaukee, Wis., has placed on the market an oil and graphite lubricator provided with an agitator that continually discharges puffs of air into the oil reservoir. This keeps the graphite uniformly mixed with the oil and obviates the trouble usually experienced when attempting to feed graphite to the cylinders of steam-using equipment. Referring to the accompanying illustration, the lever operating the lubricator is given a reciprocating motion from some external source such as the valve gear of the engine. By means of a ratchet which has four go-ahead and two retaining pawls, the lever arm causes shaft *A* to revolve in one direction, rotating the cam and causing the yoke to reciprocate vertically for each feed.

Upon the upper stroke of piston *B* the oil and graphite mixture is drawn into cylinder *M*. On the downward stroke of the piston the mixture is forced up through the check valve *C* and tube *D*, thence down through the opening *F* and the sight-feed glass to chamber *G*. From the bottom of the chamber the mixture is drawn up past check valve *H* by the downward stroke of the piston *I*. On its upward stroke the piston forces the mixture through check valve *J*, out into the feed line to the terminal check valve. In the illustration a section through the agitator nozzle is shown, but the oil and graphite feed is exactly the same. The terminal check valve is inserted in the steam pipe above the throttle or into the steam-inlet passage to the valve, and the incoming steam picks up the graphite and oil from the atomizer nozzle.

To fill the lubricator, oil is poured into strainer *K*. The quantity of oil and graphite fed for each stroke of the pump *B* is regulated by means of an adjusting nut *L*. To the lower end of the adjusting rod is attached a metal strip carrying the cylinder *M*. Turning the nut in a right-hand direction lowers the rod and sleeve so that on its downward stroke the plunger *B* does not go to the end of the cylinder. Thus, a portion of the oil remains in the cylinder and only a small quantity is forced up through the sight-feed. Turning the nut in the opposite direction raises the sleeve to its highest point and increases the feed to the maximum.

To keep the oil warm when the lubricator is used in cold places, a cored opening *N* has been provided, so that a



SECTION THROUGH OIL AND GRAPHITE CYLINDER LUBRICATOR

steam line can be connected if desired. A gage-glass shows the level of the mixture in the reservoir, and as some kinds of graphite are liable to form a deposit on the glass, a float-operated indicator is also provided. This consists of a rod *O* operated by a float *P*.

The agitator unit is exactly the same as the mixture feeding pump except that only enough of the mixture is pumped by the lower plunger *B* to provide a seal for the top plunger *I* which handles air drawn in through a vent in the top cover of the sight-feed glass. The air is compressed beneath the check valve *R* to a pressure of about 300 lb.; when the resistance of the spring is overcome, the air is discharged with a puff through pipe *S* to the bottom of the oil tank. These frequent discharges keep the graphite uniformly distributed throughout the oil. A three-way cock *T* is inserted over the check valve, so that it may be determined whether or not the agitator is working properly.

By turning the handle to the horizontal position a by-pass to atmosphere is opened, so that the discharge can be observed and the air pressure tested. On the agitator feeds the top of the adjusting rod *E* is slotted and the thumb-nut eliminated. The rod may be turned by a screw-driver and when the proper adjustment has been obtained, it is held in place by a locknut.

Norwegian Waterfall Concessions

At a cabinet council in Christiania, on Apr. 16, it was decided to bring in a bill to restrict further the existing laws of 1909 and 1911 in respect to waterfall concessions in Norway. The right of the state to regulate watersheds is confirmed in principle. Where public convenience is not interfered with and the regulated power does not exceed 500 hp. and is distant 12½ miles from another fall, no concession is necessary. Concessions will, as at present, be granted by the King, though with the proviso that where the regulated power exceeds 10,000 hp., or where considerable interests are involved, the terms of the concession must be submitted to the Storthing (parliament) for discussion. The existing maximum period of 80 years for a concession is reduced to 60 years, though in special cases, and with the sanction of the Storthing, it can be extended to 70 years.

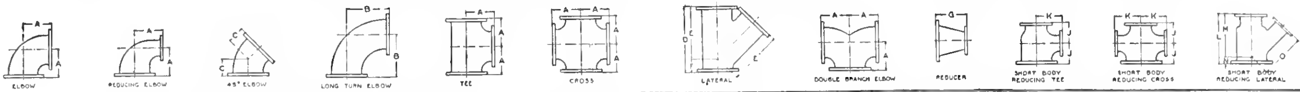
The present clause giving to Norwegian citizens and Norwegian joint-stock companies an unlimited period of concession is struck out, but is maintained in respect of Norwegian communes. At the termination of the concessional period the state can demand the transfer to it of the undertaking, with its lands, buildings, etc., without any compensation whatever. As regards concessions for a shorter period than 50 years, an amount can be fixed for the redemption by the state of the whole or a portion of the constructional work, based on the original cost of the lands, buildings and plant, according to its technical value, less amortization.

At the end of 40 years from the date of the concession the state is entitled to take over the entire proposition at its original construction cost and the plant at its technical value. This right may, if it be more convenient to the state, be postponed to periods of 10 years subsequent to the 40 years mentioned.

An important provision is an increase in the maximum royalty to the state per horsepower from 26c., as at present, to 52c., plus 26c. to the commune, or 78c. in all; though in special cases the total to state and commune can be increased to $1.04 per horsepower. There are, moreover, obligatory clauses relating to the supply to the state and commune of power at fixed prices and the use for the public of bridges and roads constructed by the party receiving the concession.

The proposed bill, the drastic restrictions of which are directed against foreign exploitation, is viewed with much disfavor by the progressive element in Norway. It is feared that its provisions with wages at the continental level, the 8-hour a day pending, and taxes at the breaking point will do away with the notion abroad that Norwegian waterpower is cheap.

THE 1915 U. S. STANDARD SCHEDULE OF FLANGED FITTINGS AND FLANGES



STANDARD WEIGHT 125 LBS. WORKING PRESSURE

SIZE	A	B	C	D	E	F	G	Short Body Red. Tees & Crosses: Size of Outlets	J	K	Short Body Red. Laterals: Size of Branches	L	M	N	O	Flanges: Diameter	Flanges: Thickness	Bolts: Diameter of Bolt Circle	Bolts: Number of Bolts	Bolts: Diameter of Bolts	Minimum Metal Thickness
1	3½	5	1¾	7½	5¾	1¾										4	7/16	3	4	7/16	7/16
1¼	3¾	5½	2	8	6¼	1¾										4½	½	3⅜	4	7/16	7/16
1½	4	6	2¼	9	7	2										5	9/16	3⅞	4	½	7/16
2	4½	6½	2½	10½	8	2½										6	⅝	4¾	4	⅝	7/16
2½	5	7	3	12	9½	2½										7	11/16	5½	4	⅝	7/16
3	5½	7¾	3	13	10	3	6									7½	¾	6	4	⅝	7/16
3½	6	8½	3½	14½	11½	3	6½									8½	13/16	7	4	⅝	7/16
4	6½	9	4	15	12	3	7									9	15/16	7½	8	⅝	½
4½	7	9½	4	15½	12½	3	7½									9¼	15/16	7¾	8	¾	½
5	7½	10¼	4½	17	13½	3½	8									10	15/16	8½	8	¾	½
6	8	11½	5	18	14½	3½	9									11	1	9½	8	¾	9/16
7	8½	12¾	5½	20½	16½	4	10									12½	1 1/16	10¾	8	¾	⅝
8	9	14	5½	22	17½	4½	11									13½	1⅛	11¾	8	¾	⅝
9	10	15¼	6	24	19½	4½	11½									15	1⅛	13¼	12	¾	11/16
10	11	16½	6½	25½	20½	5	12									16	1 3/16	14¼	12	⅞	¾
12	12	19	7½	30	24½	5½	14									19	1¼	17	12	⅞	13/16
14	14	21½	7½	33	27	6	16									21	1⅜	18¾	12	1	⅞
15	14½	22¾	8	34½	28½	6	17									22¼	1⅜	20	16	1	⅞
16	15	24	8	36½	30	6½	18									23½	1 7/16	21¼	16	1	1
18	16½	26½	8½	39	32	7	19	12 and smaller	13	15½	9 and smaller	26	25	1	27½	25	1 9/16	22¾	16	1⅛	1 1/16
20	18	29	9½	43	35	8	20	14"	14	17	10"	28	27	1	29½	27½	1 11/16	25	20	1⅛	1⅛
22	20	31½	10	46	37½	8½	22	15"	14	18	10"	29	28½	½	31½	29½	1 13/16	27¼	20	1¼	1 3/16
24	22	34	11	49½	40½	9	24	16"	15	19	12"	32	31½	½	34½	32	1⅞	29½	20	1¼	1¼
26	23	36½	13	63	44	9	26	18"	16	20	12"	35	35	0	38	34¼	2	31¾	24	1¼	1 5/16
28	24	39	14	66	46½	9½	28	18"	16	21	14"	37	37	0	40	36½	2 1/16	34	28	1¼	1⅜
30	25	41½	15	69	48	10	30	20"	18	23	15"	39	39	0	42	38¾	2⅛	36	28	1⅜	1 7/16
32	26	44	16				32	20"	18	24						41¾	2¼	38½	28	1½	1½
34	27	46½	17				34	22"	19	25						43¾	2 5/16	40½	32	1½	1 9/16
36	28	49	18				36	24"	20	26						46	2⅜	42¾	32	1½	1⅝
38	29	51½	19				38	24"	20	28						48¾	2⅜	45¼	32	1⅝	1 11/16
40	30	54	20				40	26"	22	29						50¾	2½	47¼	36	1⅝	1¾
42	31	56½	21				42	28"	23	30						53	2⅝	49½	36	1⅝	1 13/16
44	32	59	22				44	28"	23	31						55¼	2⅝	51¾	40	1⅝	1⅞
46	33	61½	23				46	30"	24	33						57¼	2 11/16	53¾	40	1⅝	1 15/16
48	34	64	24				48	32"	26	34						59½	2¾	56	44	1⅝	2
50	36	66½	25				50	32"	26	35						61¾	2¾	58¼	44	1¾	2 1/16
52	37	69	26				52	34"	27	36						64	2⅞	60½	44	1¾	2⅛
54	39	71½	27				54	36"	29	37						66¼	3	62¾	44	1¾	2 3/16
56	41	74	28				56	36"	29	39						68¾	3	65	48	1¾	2¼
58	42	76½	29				58	38"	31	40						71	3⅛	67¼	48	1¾	2 5/16
60	44	79	30				60	40"	33	41						73	3⅛	69¼	52	1¾	2 7/16
62	45	81½	31				62	40"	33	42						75¾	3¼	71¾	52	1¾	2½
64	47	84	32				64	42"	34	44						78	3¼	74	52	1¾	2 9/16
66	48	86½	33				66	44"	35	45						80	3⅜	76	52	1¾	2⅝
68	50	89	34				68	44"	35	46						82¼	3⅜	78½	56	1⅞	2 11/16
70	51	91½	35				70	46"	37	47						84½	3½	80½	56	1⅞	2¾
72	53	94	36				72	48"	40	48						86½	3½	82½	60	1⅞	2 13/16
74	64	96½	37				74	48"	40	49						88½	3⅝	84½	60	1⅞	2⅞
76	58	99	38				76	50"	42	50						90¾	3⅝	86¾	60	1⅞	2 15/16
78	58	101½	39				78	52"	43	52						93	3¾	88¾	60	2	3
80	59	104	40				80	52"	43	53						95¼	3¾	91	60	2	3 1/16
82	60	106½	41				82	54"	44	54						97½	3⅞	93¼	60	2	3⅛
84	62	109	42				84	56"	47	56						99¾	3⅞	95½	64	2	3 3/16
86	63	111½	43				86	56"	47	57						102	4	97¾	64	2	3¼
88	65	114	44				88	58"	48	58						104¼	4	100	68	2	3 5/16
90	67	116½	45				90	60"	50	61						106½	4⅛	102¼	68	2⅛	3⅜
92	68	119	46				92	60"	50	62						108¾	4⅛	104½	68	2⅛	3½
94	69	121½	47				94	62"	52	63						111	4¼	106¾	68	2⅛	3 9/16
96	71	124	48				96	64"	53	64						113¼	4¼	108½	68	2⅛	3⅝
98	73	126½	48				98	64"	53	65						115½	4⅜	110¾	68	2⅛	3 11/16
100	74	129	50				100	66"	55	67						117¾	4⅜	113	68	2¼	3¾

EXTRA HEAVY 250 LBS. WORKING PRESSURE

SIZE	A	B	C	D	E	F	G	Short Body Red. Tees & Crosses: Size of Outlets	J	K	Short Body Red. Laterals: Size of Branches	L	M	N	O	Flanges: Diameter	Flanges: Thickness	Bolts: Diameter of Bolt Circle	Bolts: Number of Bolts	Bolts: Diameter of Bolts	Minimum Metal Thickness
1	4	5	2	8½	6½	2										4½	11/16	3¼	4	½	½
1¼	4¼	5½	2½	9½	7¼	2¼										5	¾	3¾	4	½	½
1½	4½	6	2¾	11	8½	2½										6	13/16	4½	4	⅝	½
2	5	6½	3	11½	9	2½										6½	⅞	5	4	⅝	½
2½	6½	7	3½	13	10½	2½										7½	1	5⅞	4	¾	9/16
3	6	7¾	3½	14	11	3	6									8¼	1⅛	6⅝	8	⅝	9/16
3½	6½	8½	4	15½	12½	3	6½									9	1 3/16	7¼	8	¾	9/16
4	7	9	4½	16½	13½	3	7									10	1¼	7⅞	8	¾	⅝
4½	7½	9½	4½	18	14½	3½	7½									10½	1 5/16	8½	8	¾	⅝
5	8	10¼	5	18½	16	3½	8									11	1⅜	9¼	8	⅞	11/16
6	8½	11½	5½	21½	17½	4	9									12½	1 7/16	10⅝	12	¾	¾
7	9	12¾	6	23½	19	4½	10									14	1½	11⅞	12	⅞	13/16
8	10	14	6	25½	20½	5	11									15	1⅝	13	12	⅞	15/16
9	10½	15¼	6½	27½	22½	5	11½									16¼	1¾	14	12	1	⅞
10	11½	16½	7	29½	24	5½	12									17½	1⅞	16¼	16	1	15/16
12	13	19	8	33½	27½	6	14									20½	2	17¾	16	1⅛	1
14	15	21½	8½	37½	31	6½	16									23	2⅛	20¼	20	1⅛	1⅛
15	16½	22¾	9	39½	33	6½	17									24½	2 3/16	21½	20	1¼	1 3/16
16	16½	24	9½	42	34½	7½	18									25½	2¼	22½	20	1¼	1¼
18	18	26½	10	45½	37½	8	19	12 and smaller	14	17	9 and smaller	34	31	3	32½	28	2⅜	24¾	24	1¼	1⅜
20	19½	29	10½	49	40½	8½	20	14"	16½	18½	10"	37	34	3	36	30½	2½	27	24	1⅜	1½
22	20½	31½	11	53	43½	8⅝	22	15"	18½	20	10"	40	37	3	39	33	2⅝	29¼	24	1½	1 9/16
24	22½	34	12	57½	47½	10	24	18"	17	21½	12"	44	41	3	43	36	2¾	32	24	1⅝	1⅝
26	24	36½	13				26	18"	19	23						38¼	2 13/16	34½	28	1⅝	1 13/16
28	26	39	14				28	18"	19	24						40¾	2 15/16	37	28	1⅝	1⅞
30	27½	41½	15				30	20"	20½	25½						43	3	39¼	28	1¾	2
32	29	44	16				32	20"	20½	26½						45¼	3⅛	41½	28	1⅞	2⅛
34	30½	46½	17				34	22"	22	28						47½	3¼	43½	28	1⅞	2¼
36	32½	49	18				36	24"	23½	29½						50	3⅜	46	32	1⅞	2⅜
38	34	51½	19				38	24"	23½	30½						52¼	3 7/16	48	32	1⅞	2 7/16
40	35½	54	20				40	26"	26	31½						54½	3 9/16	60¼	36	1⅞	2 9/16
42	37	56½	21				42	28"	26½	33½						57	3 11/16	62¾	36	1⅞	2 11/16
44	39	59	22				44	28"	26½	34½						59½	3¾	56	36	2	2 13/16
46	40½	61½	23				46	30"	27½	35½						61½	3⅞	57½	40	2	2⅞
48	42	64	24				48	32"	29	37½						65	4	60⅝	40	2	3

EXPLANATORY NOTES

1. Standard and Extra Heavy Reducing Elbows carry same dimensions center to face as regular Elbows of largest straight size.
2. Standard and Extra Heavy Tees, Crosses and Laterals, reducing on run only, carry same dimensions face to face as largest straight size.
3. If Flanged Fittings for lower working pressure than 125 lbs. are made, they shall conform in all dimensions except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.
4. Where long turn fittings are specified, it has reference only to Elbows which are made in two center to face dimensions and to be known as Elbows and Long Turn Elbows, the latter being used only when so specified.
5. All standard weight fittings must be guaranteed for 125 lbs. working pressure and extra heavy fittings for 250 lbs. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.
6. All extra heavy fittings and flanges to have a raised surface 1/16" high inside of bolt holes for gaskets. Thickness of flanges and center to face dimensions of fittings include this raised surface.

   Standard weight fittings and flanges to be plain faced.

   Bolt holes to be 1/8" larger in diameter than bolts.

   Bolt holes to straddle center lines.
7. Size of all fittings scheduled indicates inside diameter of ports.
8. Square head bolts with hexagonal nuts are recommended.
9. Double Branch Elbows, Side Outlet Elbows and Side Outlet Tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees and elbows.
10. Bull Head Tees or Tees increasing on outlet, will have same center to face and face to face dimensions as a straight fitting of the size of the outlet.
11. Tees, Crosses and Laterals 16 inches and smaller, reducing on the outlet, use the same dimensions as straight sizes of the larger port.

    Sizes 18 inches and larger, reducing on the outlet, are made in two lengths depending on the size of the outlet as given in the table of dimensions.
12. For fittings reducing on the run only a long body pattern will always be used.

    Y's are special and made to suit conditions.

    Double Branch Elbows are not made reducing on the run.
13. Steel Flanges, Fittings and Valves are recommended for Superheated Steam.

This schedule, superseding all previous issues, was adopted Mar. 20, 1914, by a Joint Committee of the National Association of Master Steam and Hot Water Fitters, the American Society of Mechanical Engineers and the Committee of Manufacturers on Standardization of Fittings and Valves, and became effective Jan. 1, 1915. All dimensions are in inches. Copies of the original chart, of which this is a reproduction, on heavy paper, 24x36 in., can be secured for $1 by addressing the National Association of Master Steam and Hot Water Fitters, 260 Broadway, New York City.

Editorials

Classification of Technical Literature

On another page is reported the organization by some twenty national technical and scientific societies of a Joint Committee on Classification of Technical Literature. As its name indicates, its purpose is to propose a standard method of classifying technical literature so that filing may be facilitated and the valuable things which are being forgotten and practically buried in the back numbers of periodicals or other sources of information may be kept easily available.

The problem before this committee is three-fold. First, to arrange a complete classification of subjects in the wide fields of technology and applied science. Second, to select or develop a notation or system of indexing for the subjects classified. Third, to set before the publishers of technical journals and books, and societies that print technical and scientific transactions and proceedings, the value of adopting the accepted classification and notation.

From the deliberations of this committee will undoubtedly come suggestions as to ways in which the papers can coöperate. It goes without saying that Power will be glad to do its part in any such way, and undoubtedly all others will be similarly disposed, for it will be to their interest to have the value of their issues made more enduring.

Power is not insensible either of the honor of having its editor chosen as the first chairman of the committee.

Side Lights on Hydro-Electric Plant Service

To many engineers, service in a hydro-electric generating station means almost exile. They dread the prospect of spending years in a plant situated, as they often are, many miles from a city, in a rough or mountainous district. Others see in it opportunities for maintaining a little country home and a pocket-sized farm as a "side line," but fear that the work itself will lack interest because of the absence of steam equipment, the few men required to handle the installation in normal service, and the apparent simplicity of the operating routine. They feel that the opportunity to grow may be denied the water-power plant operator—that a job of this kind may be good enough for an elderly man who fancies solitude and enjoys grubbing in a garden and counting eggs, but that it cannot appeal much to an engineer with real "pep" in his makeup.

For some men this point of view is so ingrained that it would unquestionably be a false move to accept a position in a station of this kind. It is, no doubt, partly a matter of taste whether an engineer will find satisfaction in a steam plant in the town or in a water-power station many miles from the allurements of city life. But, granted the importance of applying the personal equation to hydro-electric plant service in remote localities, it is worth realizing that this kind of work may possess both interest and opportunity if a man takes advantage of his chances. The casual visitor to a hydro-electric plant in the wilderness goes away with the impression that there is comparatively little apart from routine work for the operating staff to do. It seems to the layman merely a question of opening the gates and letting the water run through, and the wheels do the rest. Beyond oiling the governors, keeping an eye on the lubrication of main-unit and exciter bearings, putting down the half-hourly instrument readings on the log sheet and watching out for possible damage from thunder storms, life appears to be one glad, sweet song. Wages are moderate, to be sure, but the little farm does the rest, thinks the visitor, and seldom does anything arise to disturb the poise of the operating shifts.

Brethren of the water-power service know better. They appreciate that under normal conditions, with everything running smoothly, the days sometimes do seem a bit long, but the wise ones in this work find fully as much to learn as do their steam-plant brothers in the town. It is true that the design of a hydro-electric station generally "stays put" and that capital errors in layout can be corrected only at relatively high cost. In its general arrangements such a plant is a pretty rigid affair, but this does not mean that skill is not necessary to operate it efficiently. Waterwheels and generators have their economical range of output no less than steam-driven machines, and conservation of storage facilities is as important in many plants as the careful use of fuel in steam stations. The relations of weather conditions to stream flow, the changes in effective head on the wheels, accuracy with which the governing equipment operates, effect of wear in turbine blades and passages upon water consumption, prevention of ice formation within wheels, proper handling of sluice gates, and the study of voltage regulation—all challenge the interest of the engineer of inquiring mind. The opportunity for the installation of home-made apparatus in the auxiliary branches of water-power plant service is large, notably in connection with the remote control of head-gates, the prevention of leakage, recording of river, reservoir and tail-race elevations, economical repairs, and improved lighting and small power applications. When a hydro-electric plant operates in parallel with one or more other stations, the possibilities of utilizing water efficiently become even more interesting and important. The reduction of waste has not received the attention it should in some stations, while in others it has gone to such refinements as the installation of special meters for water-flow records, the subdivision of local lighting and power circuits, the inclosure of operators' quarters in electrically heated spaces of limited size, use of the more efficient types of lamps, and recirculation of transformer cooling water.

In emergencies the operator's skill is taxed to maintain continuous service, no less than in steam stations. The isolation of line troubles is almost a specialty in itself.

The man with a leaning toward investigation will find plenty to occupy himself with if he confines his attention for a time to the good points and shortcomings of alternating-current relays in relation to trouble detection and segregation on the system at large. The study of lightning protection is another big subject, worthy of unusual ability, and we repeat the profound interest always associated with the subject of waterwheel governors. As a factor in securing an all-round experience in power production, the water-driven station will be in the running for a long time to come. Its isolation but gives the keen student of this branch of engineering better opportunity to master this part of his profession. Few indeed are the cases where the mails will not bring the benefits of the technical press just as well as in the city. The laws of power production are universal in scope, and if the operator refuses to yield to the temptation to live a routine life and sticks to his purpose to become an expert on the work with which he is engaged, location becomes of secondary concern for the time being and opportunity absorbs him to a degree but little realized by the fellow who thinks that water-power service is narrowing to ambition.

State Aids Kansas Engineers

The commendably generous offer made by the Kansas State Agricultural College to assist in the educational program of the National Association of Stationary Engineers of that state will most likely be accepted. State and municipal educational institutions of an engineering or technical character might well consider following Kansas' lead.

The college offers to direct a course of study under the auspices of the State association, each subordinate association to have at least three lectures a season by a representative of the college. Special lectures on subjects allied with power-plant operation will also be given. The college aims to send out questions and references to each association. Every sixth lesson will be in the nature of an examination, the results of which will be reported to the college. The associations are expected to pay for only the traveling expenses of the lecturers; this outlay to be met by special assessment. It is the intention to begin the course July first.

The National Educational Committee of the association supports a program similar to that offered by the Kansas Agricultural College. It would seem that both programs could be carried out to the advantage of all concerned.

Cleanliness in Refrigeration Plants

To the mind of the layman cleanliness implies absence of dirt. To the engineer it means, or should mean, absence of anything foreign to the machine or apparatus or its functioning. As someone has said, "Dirt is matter out of place."

The refrigeration plant is a place of transmissions. Not the noisy, evident processes heard and seen in turbine or engine rooms or in shaft alleys or belt races, but the quiet, invisible transmission of heat through metal walls. You cannot see it. Sometimes in some places the hand, sensitive as it is to temperature differences, cannot inform even approximately how effectively this transmission, which is so vitally necessary to the plant's efficiency, is going on.

Elaborate, extensive and expensive tests have been conducted to reduce to accurate figures the losses due to scale in boilers, because scale is an undesirable insulator between heat and the water that should absorb it—because it is dirt; because it is foreign.

The refrigeration plant is a great rendezvous of similar foreign substance or substances having similar effects. If the condensers are scaled the heat-laden ammonia cannot get rid of its heat as it should, and it starts on its heat-absorbing journey handicapped and partly incapacitated. If this were all it would not be so bad; but when this ammonia arrives at the working place, at the cooler and the coils, the same coils may be so insulated with ice or scale, or both—and both are foreign, both may be considered dirt, because they are matter in the wrong place—that the half-able ammonia cannot even do what it is willing to do. The compressor water-jackets, the absorber, the generator, the precooler, the cooling tower—all may be likewise coated with dirt. Even the noncondensible gases may be considered as dirt and are worse than scale or ice, because they circulate.

The whole system must be as clean as a freshly laundered shirt if it is to work well. How to keep it clean and working well is the engineer's job. He is the laundryman as well as the maker of the shirt, which in this case happens to be refrigeration. The articles now appearing in POWER tell him in that good old shop-talk way how to do it best. They are useful articles, these; and we hope to have more of them.

Motor Records Again

Engineers in charge of industrial power plants are more and more being made responsible for the quality of motor service rendered on the premises. Even where the establishment carries one or two electricians on its payroll, the chief engineer is likely to be blamed for motor troubles, and the anticipation and prevention of these deserve some attention. Motors of the induction type, if built by reputable concerns, will stand a large amount of abuse, it is true, but the furnishing of efficient service is today demanded almost as much as regular operation, and superficial knowledge of what the local motors are doing is a pitfall into which the steam engineer in executive charge of this branch of the installation should not allow himself to fall.

The larger the plant, the more justifiable it is to keep accurate records of the repair items on individual machines, the performance of different makes, any tendencies toward heating of bearings or moving parts, and the repeated need of adjustment of air-gap conditions, alignment of bearings, or commutator difficulties, where direct-current motors are used. The value of card-index test records of loads carried has been emphasized in these columns; of equal importance is the maintenance of a high power factor in alternating-current installations. Protracted underloading of individual motors leads to overheating of generators from excessive idle current, and the study of manual versus solenoid control for motors on machine tools is one of large interest.

Correspondence

Depth of Stuffing-Box

The writer has had the same trouble with an outside-packed pump as described by C. E. Sherman in the issue of Apr. 6, 1915, page 481. In my case it was overcome by fitting a dummy packing of lignum-vitæ two inches deep and filling the stuffing-box with soft packing. This means of packing removed all trouble and considerably reduced the friction losses.

For low pressures white-metal shavings, with a turn of soft packing before and after, will give good results.

E. R. PEARCE.

Rochdale, England.

Isometric Drawings

Most power-plant engineers can make pencil sketches of the general appearance of parts of machinery, showing the dimensions and thus conveying the desired information to others. Most men would probably draw freehand two or three views on the back of a report sheet and write in such information as they thought the drawing failed to give. A sketch in isometric perspective, or sort of a bird's-eye view, necessitates but one view and is easy to make, yet engineers generally think it beyond their ability. Such a sketch shows the parts in their true relation best and is really easier to draw.

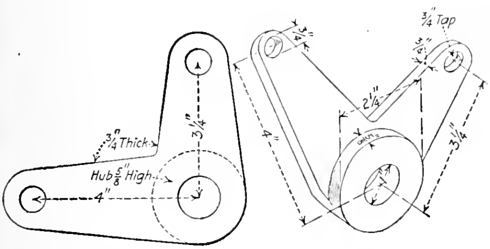


FIG. 1. FIG. 2.
ADVANTAGES OF ISOMETRIC SKETCHES

In a number of cases repair parts made from drawings capable of being misinterpreted have resulted in expensive mistakes. One instance will illustrate. A Corliss engine broke one of the bell cranks. The engineer took the gear apart and sent a helper in with a sketch of the broken piece, Fig. 1. I could see that he had laid the broken crank on the paper and drawn a line around it, and then put on such dimensions and notes as he thought were necessary. The hub was shown dotted and there was a chance for a misunderstanding as to which side the hub should be on, so I phoned to him for the old casting. For some reason he refused to part with it and told me to make it "just as it says on that paper—and be quick about it," for he had to start up at 6 : 30 o'clock.

It was forged out, finished and delivered after working hours. Next morning there was a phone call for another crank made with the hub on the other side, "where it belongs." The second crank was made as shown in Fig. 2, but there was trouble when the bill for two cranks was presented. Fortunately, we had retained the engineer's drawing and the first crank.

The bill was not paid until a competent person had passed on the correctness of the work. Of course, the intentions were all right, but the mistake was in showing the hub by dotted lines, indicating a lower or invisible surface according to the rules of drawing. The engineer had not known this and had committed the error.

A little time spent in practice will make anyone fairly proficient in sketching. It is interesting and is helpful even when correct three-view drawings are at hand.

DONALD A. HAMPSON.

Middletown, N. Y.

Clean New Steam Lines

Although steam has been used commercially for one hundred years or more and steam regulating and economizing devices have been constantly increasing, many engineers are still ignorant as to certain vital points. The greatest trouble we find is that a large percentage of engineers (and this refers to the educated men as well as the ones in overalls) will connect up an entirely new line and blow dirt, grease, white lead, red lead, iron turnings and dirt generally through separators, reducing valves and steam traps and all other devices.

Cannot you start a campaign of education along these lines? We advise wherever we have an opportunity to do so that the lines be blown through for at least forty-eight hours before connecting up the devices. Of course this wastes a lot of steam, but it is paid for a hundred times over in the avoidance of subsequent trouble.

E. E. STRONG, PRES.,
The Strong, Carlisle & Hammond Co.

Cleveland, Ohio.

Explosions in Boiler Furnace*

I have read the discussion on this subject for the reason, chiefly, that we have had similar trouble, although so far no damage has been done. Mr. De Blois in the Apr. 30 issue states that his boilers are equipped with underfeed stokers. [These are of the Jones type.—EDITOR.] We have four boilers, horizontal water-tube, equipped with underfeed stokers (Taylor), and on several occasions there have been explosions which occurred while the fire was being worked. I have studied the conditions and believe the trouble is caused in the following manner:

The arrangement of this furnace is such that the coal is pushed into a trough, or retort, by the slow-moving plungers. It is then worked forward and upward by the plunger and incoming coal. When the coal first enters the retort it is fine and closely packed and sometimes

*See "Power," Apr. 30, p. 553; May 11, pp. 651, 652 and 653, and May 25, p. 719.

quite damp, as we wet the coal in the bunker to keep the dust down.

The air holes in the tuyeres are above this trough and about at the level where coking takes place as the coal is moved forward in the furnace. With ordinary crushed bituminous coal, usually quite fine, the greater part of the volatile hydrocarbons are driven off at about this point in the furnace and pass through the incandescent fuel bed above to the combustion chamber. After a few hours' firing a clinker will form on the tuyere plates, which partly obstructs the air passages through the tuyeres and which must be broken up and removed with the slice-bar. This is done through the small side doors. Sometimes it can be done without disturbing the green coal below the tuyeres, and at these times there have been no explosions. But at other times the upper part of the fire, or the incandescent fuel bed, is so broken or so light after getting the clinkers out that it is necessary to break the bed of green coal to level the fire. This liberates a large quantity of rich gas which is below the level of the air openings and has not a good chance to mix with the air coming through the tuyere holes. As this gas rises it comes directly across the path of the high-velocity incoming air and forms a large volume of gas that is explosive and does explode when ignited by the incandescent coke and hot side walls of the furnace. In some cases the flames, usually accompanied by a shower of sparks which I think are particles of coal dust that have been ignited, have shot out of the small doors and into the fireman's face. When the fresh coal was quite wet this explosion was sometimes strong enough to blow open the side doors. The reason that wet fuel causes a more violent explosion is, I think, because the coal is packed more closely and does not allow the gas to escape readily until the fuel is broken up with the bar.

The air pressure in the wind-box at the time these explosions occur is usually about 1.8 to 2.5 in. of water. The boiler damper is usually wide open, and the draft over the fire is maintained at about 0.2 to 0.3 in. of water in the front pass.

Mr. De Blois asks for suggestions as to how to prevent these explosions. I do not know how his furnace is constructed or how the fan is controlled, but in our case the speed of the fan engine, which also drives the stokers, is controlled by a damper regulator which, instead of being connected to the dampers, is connected to a butterfly valve in the steam line to the engine. When the pressure drops about 1 lb. the engine speeds up to about 450 r.p.m. This creates considerable air pressure in the tuyeres, as the steam pressure is usually a little low at this time, and when the green coal is moved with the slice-bar a large volume of explosive gas is liberated.

As a remedy for this trouble I would suggest two changes in the operation, either of which will bring about similar results. First, before the fires are worked with the bar in cleaning or leveling, close the gate in the air-supply pipes, which the fireman will probably not do unless specially instructed. Second, change the methods of control of the fan so that the air pressure will be constant and will change only as the load changes, or in other words, make the air pressure proportional to the load carried by the boilers. The first change will prevent sufficient air from entering the furnace at the time when the rich gas is being driven off to cause an explosion, the gas escaping to the stack. The doors are so small that only a small volume of air can enter at this point, and the air that can filter in through the setting at this low draft pressure is negligible so far as explosions are concerned. The second change would give an even air pressure at all times and might prevent a proper mixture of explosive gas. It also has the advantage of giving a uniform rate of combustion with only the minimum amount of excess air, a condition which makes for economy.

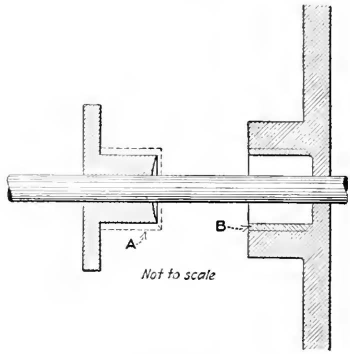
I have never known an explosion to occur except when the front doors were open, but this is the time when the coal is being disturbed, and the air probably comes through the tuyeres instead of through these doors.

J. C. Hawkins.

Hyattsville, Md.

Changed Proportions of Stuffing-Box

After having a great deal of trouble with the packing on one of my engine rods, I overcame it as follows:



Stuffing-Box Bushed

The rod was 2 in. and the packing 7/8 in., which is too large for a rod of that size, so I made a bushing 1/4 in. thick and drove it into the stuffing-box, as at *B*, turned 5/16 in. off the gland at *A* and used 5/8-in. packing, which works to perfection. This engine makes a 60-day run of 24 hours without a stop, with a piston speed of 400 ft. There has been no trouble with the packing during the last 45 days.

M. J. Merrell.

St. Louis, Mo.

Grouting under Heavy Machinery*

With small engines—those weighing six or seven tons—six wedges, 2 in. wide, 8 in. long and 1/4 in. thick at the point by 5/8 in. at the butt, are quite sufficient if distributed one at each corner and one in the middle of the frame at each side and all removed as soon as the grout has set. When the engine has been leveled up with a 5/8-in. space left for grouting, a dam of clay or mortar should be built around the bed so as to let the grout stand two inches up the side of the bed. The grout should be two parts clean, sharp sand and one of cement.

*See previous discussion, Mar. 2, p. 310; Apr. 6, p. 482; May 4, p. 620.

mixed to the consistency of thick buttermilk and run in (the bolt holes having first been surrounded with clay). Mr. Wilson speaks of borings and ammonia; this is all right for small jobs, but hardly feasible with a big machine.

The old-fashioned way of bedding down to a stone bed was good, as the stones were very little affected by oil, whereas many foundations have been ruined by oil getting between the bed and engine.

Care should be taken to remove all traces of oil before pouring the grout and it should not be allowed to set too quickly. This may be retarded in a hot room by covering the exposed parts with burlap which should be kept wet. Always make sure that there is a free escape for the air from the inside of the box beds, otherwise the grout will not flow evenly to all parts.

E. R. PEARCE.

Rochdale, England.

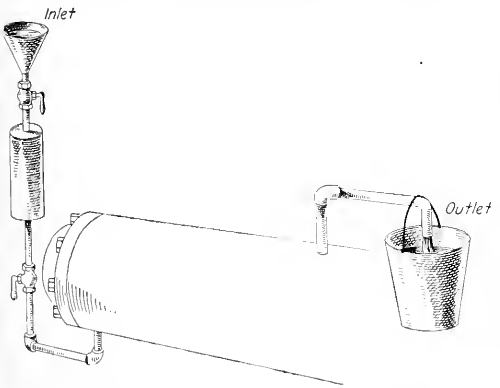
In the issue of Apr. 4, p. 620, J. E. Poche advocates using iron wedges in leveling up machinery preparatory to grouting in. Wedges of this kind serve very well for leveling up, but should not be left in as he recommends, as the base of the machine will rest on the wedges and not on the concrete. We tried it once and had to dig the grouting out and do the job over, because of the engine sliding on the iron wedges. I prefer wedges of hardwood for this work.

J. O. BENEFIEL.

Anderson, Ind.

Removing Scale from Inside of Water Jacket

The cooling water, which contained a large amount of sulphate of lime, for an air compressor (12¼x18¼x12 in.), had been throttled, and it raised the temperature of



ACID PIPED INTO WATER JACKET TO REMOVE SCALE

water so that it deposited inside of the cylinder jacket a hard scale which we could not get at to remove with tools. I used muriatic acid piped through as shown in the illustration, and it worked fine. It took ten gallons at 60c. per gallon to do the job.

To operate, close the lower valve and fill the reservoir with acid, then close the upper and open the lower valve. The acid forces its way through and disintegrates the scale in the jacket. I used the acid over again as long as it had any strength.

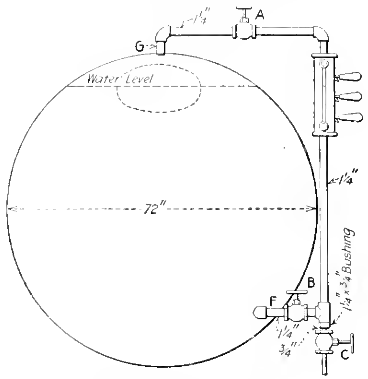
W. A. HENDRY.

Grinnell, Iowa.

Queer Action in a Water Column

I hesitate to tell the following experience with a 72 ft. by 17 ft. 6 in. horizontal return-tubular boiler, for I would not believe it myself until I had actually seen it.

The boiler had been out of service for a few days for cleaning and repairs. When it was ready again the



WATER COLUMN AS CONNECTED

fireman replaced the manheads and started to fill it with water. (It has been the custom at this plant when filling a boiler to leave all connection closed till an air pressure of about 20 or 30 pounds has been reached; then, if either manhead gasket is defective it will show it at this pressure and can be changed without having to pull the fire.) When the fireman returned to this boiler he found the water showing at the top of the water-glass. He immediately shut off the water-feed valve and opened the blowoff to drain out the water to the proper level for firing up. But he had no sooner opened the blowoff valve than the water disappeared in the gage-glass and did not return. He then closed the blowoff and opened the feed-water valve, and the water immediately rose to the top of the glass again. He repeated this performance several times, with the same result each time, and then called in the foreman who also obtained the same results. He then shut both the blowoff and the feed valves and opened valve *C* (valves *A* and *B* being already open), and there was a strong suction of air into the boiler. Valve *B* was next closed, with valves *A* and *C* open, and water rushed out with considerable force. Valve *A* was then closed, with *B* and *C* open, and the water immediately stopped running, but there was no suction. On opening valve *A*, however, with valves *B* and *C* open, the suction commenced again and the water could be seen rushing upward through the gage-glass.

These valve changes were made many times, with the same results. With valves *A* and *B* open and *C* closed, the water sometimes showed at one height in the glass and sometimes at another. It finally came to rest at a point a little below the third gage-cock, but the suction continued when valves A, B and C were opened, and water rushed out when valve B was closed, with A and C open, as before.

It was finally decided to take out the rear manhead to see the actual location of the water level. Before doing this, however, valves A, B and C were again opened and the suction was as strong as ever. Valve C was closed and the water level, after some fluctuation, came to rest in the glass a little below the third gage-cock. The rear manhead was then loosened, but instead of falling in as was expected, there seemed to be a heavy pressure holding it in place. It required several sharp blows with a heavy bar to loosen the head. When it was finally driven in air and water spurted out as if from heavy pressure. The water level was found to be about as the level in the glass had last shown it.

The boiler was then emptied and all the pipe connections of the water column removed and examined. The lower horizontal pipe marked F was partly closed with scale, but still had a free opening of ample area, and the rest of the pipe and the water column itself were perfectly clear.

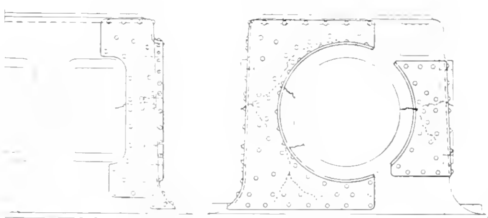
Now, if anyone can satisfactorily explain how vacuum and pressure can exist in the same boiler at the same time I would like to see the explanation published in POWER. Also, why and how did the water siphon out of the boiler in a continuous stream when valve B was closed with A and C open? Pipe G did not extend through the shell of the boiler more than ½ in., and the water level was eight or ten inches below it.

F. F. JORGENSEN.

Gillespie, Ill.

Repairing Gas-Engine Housing

On one of the three-cylinder vertical 200-hp. gas engines in the local electric-light plant the housing was broken as shown by the heavy dotted lines in the illustration. The fracture began at the end bearing seat and continued around the corners and along both sides, terminating at the manholes in each side. On one side of the end



SHOWING HOW PLATE WAS RIVETED TO HOUSING

vertical center line the break extended upward and downward until there was practically no support for the bearing and shaft and part of the weight of the revolving part of the generator.

The builders of the engine advised that the least time in which they could furnish a new casting completely machined would be three weeks, which meant a serious delay for the lighting company.

A local firm guaranteed that it could repair the housing in three days from the time of delivery at its works. The offer was accepted, and a very substantial job was accomplished. The repair plates are $\frac{9}{16}$-in. boiler plate formed to fit the casting as shown, and special care was exercised to make a good fit around the circular flange at the bearing seat. Where possible the plates were secured to this flange with ¾-in. machine screws fitting in reamed holes that penetrate sufficiently into the casing flange to insure a true surface for the end face of the bearing. In the other parts ¾-in. rivets were used, and around the corners these extended through, with heads against the fillets on the inside of the housing.

On the whole this repair job, while a big one, is entirely satisfactory, and besides saving much time, proved cheaper than a new housing.

Franklin, Penn. M. E. GRIFFIN.

Priming Centrifugal Pumps

Having read the several letters in recent issues of POWER* relative to priming centrifugal pumps, I submit the following description of a method that I used successfully on a three-stage pump. This was connected to 21 drilled wells and discharged into a standpipe about 160 ft. above the pump. The wells were divided, ten on one and eleven on the other side of the pump, with a check valve in each lead.

An old belt-driven air compressor was used as a vacuum pump, and the suction was connected between the wells and the check valves. The suction pipe was run up through the chimney, which gave it a total height of 40 ft., so that the pump would not draw water into the cylinder. The pump suction pipe between the check valves and pump was filled with water and the air pump started. After the air was exhausted from the suction pipe, the centrifugal pump was started.

Marshfield, Wis. LOUIS B. CARL.

The letters on this subject appearing in recent issues of POWER are interesting and instructive.

About two years ago I installed four centrifugal pumps, each of which had a suction lift from 12 to 16 ft. The suction pipes were from 4 to 10 in. in diameter and the discharge pipes 4 to 8 in. Two of the pumps were used for pumping sewage and two for clear water. The speed was from 1250 to 1500 r.p.m., the discharge lift from 30 to 70 ft. Each suction pipe had a foot valve (they could not be kept tight on the sewage pumps) and a strainer at the inlet end. There never was any trouble in priming these pumps. The facilities for priming consisted of a 2-in. pipe connected to a tank 30 ft. above the pumps. The tank was always kept full of water.

A 1-in. branch pipe from the 2-in. line was run to each pump and a 1-in. straight-way valve put in each branch.

All the pumps had water-sealed shafts and were direct-connected to alternating-current motors from 35 to 125 hp. The valve on each discharge pipe was opened only after speeding up the pumps. From two to four minutes was the time required to prime. A vacuum gage was at-

*"Power," Mar. 2, p. 294; Apr. 6, p. 481; Apr. 20, p. 550; May 4, p. 615

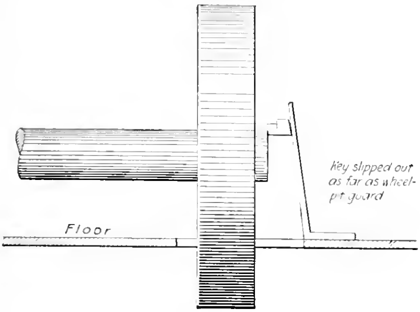
tached to each suction pipe and a pressure gage to each delivery pipe between the pump and the delivery pipe valve.

James E. Noble.

Toronto, Ont.

An Accident Prevented

The illustration shows how a sheet-iron wheel-pit guard prevented a flywheel from slipping off the shaft and probably causing serious damage. The diameter of the wheel is only 30 in., but it is in such a position that had it slipped off it would have wrecked the main unit of the isolated plant. One of the attendants noticed that the wheel was not running true, and it was found that the key was very loose and a new one had to be made.



Key Held in Place by Guard

Samuel L. Robinson.

Providence, R. I.

Comment on Turbine Lecture

I have read C. H. Bromley's lecture on steam turbines in the May 11 issue. In the latter part he offers suggestions on starting and running a turbine, and it does not appear to be clear what type of machine he had in mind.

To pick out one or two statements: "Now close the drains of the stages. The gear may then be oiled. The main turbine may vibrate considerably while being brought up to speed" . . . "to get the rotor above the 'critical speed,' when the vibration will ordinarily cease."

Mr. Bromley's opening remarks undoubtedly refer to a multi-stage turbine; in fact, one might gather that he has particular reference to a Curtis vertical machine. He then appears to refer to a De Laval single-stage impulse turbine in the same breath, as it were, for no multi-stage units are built with shafts which run above their critical speeds; in fact, to my knowledge this characteristic is peculiar to the original single-stage impulse De Laval, with its flexible shaft. I might also add that if the gears which Mr. Bromley mentions did not receive oil immediately they started to revolve, instead of after the load was thrown on, the heat generated would soon cause abrasion of the teeth.

He refers also to clearances between the blade teeth and the casing. As every turbine man knows, the radial clearances for an impulse turbine can be much greater than for a reaction, due to there being no pressure difference between the two sides of any one wheel, whereas with the reaction type these must be reduced to the smallest practical amount. There are also other statements on which comment might be made, such as, "sometimes an elevated tank is used for supplying oil at starting and stopping." The gravity system, comprising the elevated tank with cooling coils and filter placed below, is in general use.

R. N. Austin.

Toronto, Ont., Can.

I was much interested in Mr. Bromley's lecture on the steam turbine, appearing in the May 11 issue of Power, particularly in his instructions for starting.

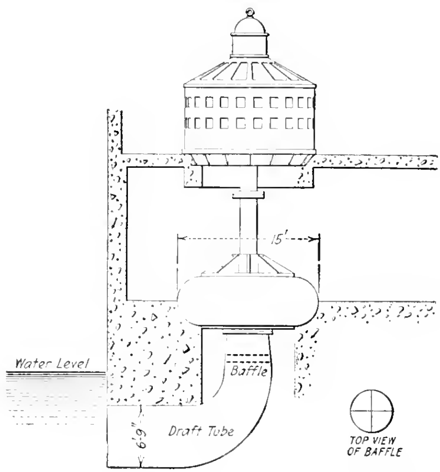
He says the turbine may vibrate considerably while being brought up to speed and that the admission of a little more steam quickly to get the rotor above the "critical speed" will ordinarily cause the vibration to cease. Although his instructions seem to apply to the Curtis turbine, this point is also true of the Westinghouse machine. If, however, the turbine is started about fifteen or twenty minutes before it is needed for the load and slowly brought up to speed, the vibration at the "critical speed" will be reduced to a minimum and in some cases done away with altogether.

John Tooker.

Richmond Hill, N. Y.

Draft-Tube Water-Hammer

Recently, there was installed in our plant, a 15,000-hp. waterwheel driving an alternator. The plant operates under 375-ft. head and the unit runs at 375 r.p.m., the pressure at the waterwheel being 158 lb. When operating at $\frac{5}{10}$ gate opening, it was found that water-hammer occurred in the draft tube, causing the pressure in the pipe line to rise 25 lb. and starting leaks in the 7-ft. wooden-pipe line.



Baffle in Draft Tube Stopped Water-Hammer

The theory of the engineer was that, owing to the construction of the draft tube, the velocity of water at that particular gate opening was such that the whirling motion through the wheel set up a counter-current in the center of the draft tube, causing the water to come back into the wheel and raising the pressure. The vacuum gage in the draft tube varied from 15-in. vacuum to 5-lb. back pressure under this condition of water-hammer.

The engineer stated that a baffle placed in the draft tube to break up this whirling motion would cure the trouble, and a piece of boiler plate 1 in. thick and 18 in. wide was then placed therein, as shown in the accompanying sketch.

This cured the difficulty and since then no trouble has been experienced.

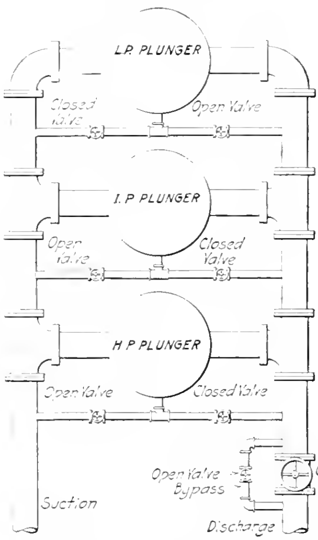
J. B. Crane.

Duluth, Minn.

Moving Pumping Engines by Water Pressure

Handling pumping engines of the large sizes calls for a method of procedure peculiar to itself. They must be moved a small distance at a time and also held securely in position.

Multiple-expansion pumping engines are not usually built with reversing gears, and it is customary to move



Pipe Connections for Water Pressure

them forward or backward a small amount with water pressure. I submit the simple illustration of the pipe connections to the plungers and valve chambers of a twenty-million gallon pump.

The engine is of the vertical triple-expansion type. The three cranks are set at 120 deg. apart. We have access to a 100-lb. water pressure which is brought to bear under the plunger whose crank happens to be in position to be raised. This moves the entire engine. By the manipulation of a set of bypasses the discharge area, plunger chamber and suction area are thrown open to water pressure and release as desired.

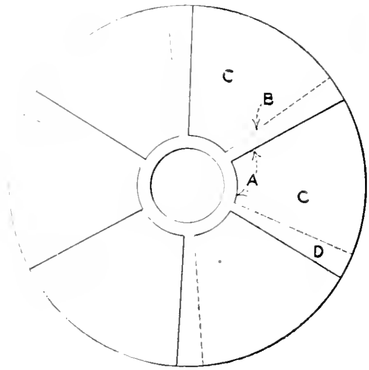
Edward T. Binns.

Philadelphia, Penn.

Increasing the Flow of Water

An appliance for increasing the amount of water that will flow through the outlet of a shallow tank when the depth of the water does not exceed three times the diameter of the outlet may be easily made in the following manner:

Cut a sheet-metal disk of suitable thickness four times the diameter of the outlet, and a hole in the center of



Disk over Tank Outlet

the disk the size of the outlet. Lay out the flange in six equal parts (see illustration). Cut the disk on the full lines marked *A* and bend on dotted lines *B*, bringing the planes *C* to a vertical position and at right angles to *D*, thus forming six wings. Place the appliance directly over the outlet, using the plane *D* as the base. The plane *C* eliminates the whirling motion of the water and allows it to run out in a steady stream.

E. A. Buchanan.

Coffeyville, Kansas.

"Unusual Opportunity" for the Fireman

When it comes to versatility for the fireman we certainly have to hand it to North Carolina. In this state he can assume such rôles as best meet any and all occasions, playing the part of fireman, scrubman, bath artist, etc., with full permission of the law. In fact the law helps him to it, as shown by the following interesting extract from the State Public General Laws of 1911, and now operative:

Section 1 (Chapter 156). That the fireman of the Supreme Court building shall be appointed by the chief justice and associate justices of the Supreme Court, and when not engaged in his duties as fireman shall act as assistant janitor of the Supreme Court, and shall assist in the cleaning and care of the Supreme Court and perform such other duties as may be designated by the said justices of the Supreme Court.

This law, granting these great privileges, is the noble work of the General Assembly. How many members of that honorable body ever visited a boiler-room to learn what firing really meant?

L. R. W. Allison.

Newark, N. J.

Inquiries of General Interest

Long-Range Cutoff for Corliss Engine—How can long range of cutoff be secured with a Corliss engine?

J. C. H.

By supplying the engine with a separate eccentric for operation of the steam valves.

Submerged Piston vs. Straightway Pump—What is the difference between a submerged piston and straightway pump?

W. C. O.

Submerged piston pumps are like the ordinary duplex feed pump with both suction and discharge valves above the water pistons, the latter being submerged, while in the straightway pattern the suction valves are below and the discharge valves above the water pistons.

Terminal Pressure—What is meant by terminal pressure?

S. H. J.

Terminal pressure is the pressure that would be in the cylinder at the end of the stroke of the piston if the exhaust valve did not open until the stroke was completed. On a steam-engine indicator diagram the terminal pressure may be found by extending the expansion curve to the end of the diagram. The theoretical terminal pressure is found by dividing the pressure at cutoff by the ratio of expansion.

Piston Displacement—What is meant by the term "piston displacement"?

C. A. G.

Piston displacement is the space, usually reckoned in cubic inches, through which the piston sweeps in a single stroke. It is found by multiplying the area of the piston, in square inches, by the stroke in inches. The displacement of a pump piston would be the number of cubic inches of water discharged by one stroke, if there were no leakage or slippage.

Spouting Velocity of Liquid—What is the "spouting velocity of a liquid?

S. H. H.

The velocity with which a liquid under pressure issues from an orifice, and unless otherwise qualified, the term is used to signify the theoretical velocity that would be due to the head or pressure of the liquid at the entrance of the orifice, as given by the formula,

$$v = \sqrt{2gh}$$

in which

v = Velocity in feet per second;

$2g = 64.32$;

h = Head in feet, equivalent to the pressure.

Absolute Pressure for Inches of Vacuum—What would be the absolute pressure with 26 in. of vacuum and 29.5-in. barometer?

M. W. C.

Inches of vacuum signifies pressure in inches of mercury column below the pressure of the atmosphere; hence, with a barometer reading of 29.5 in., 26 in. of vacuum would represent an absolute pressure of

$$29.5 - 26 = 3.5 \text{ in. of mercury.}$$

At ordinary temperatures each inch of mercury may be taken as equal to 0.491 lb. per sq.in., therefore the absolute pressure would be

$$3.5 \times 0.491 = 1.7185 \text{ lb. per sq.in.}$$

Stacks Mounted on Boiler Settings—What are the advantages or disadvantages of having independent steel stacks set directly over the front smoke connections of return-tubular boilers?

W. L. B.

Stacks erected in that manner have the advantages of affording direct and independent draft and a saving of ground or floor space required for independent bases and foundations. They have the disadvantages of requiring special supports and also of usually requiring reinforcement of the front ends of the boiler settings to prevent the settings from being racked by wind movement of the stack. They also present difficulties in providing protection of the front end of the boiler and setting from damage by rain water carried down inside or outside of the stack.

Designation of Superheated Steam—How is the amount of superheating of steam designated and how is it usually determined?

S. W.

Superheating is designated in degrees of superheat, meaning the number of degrees by which the actual temperature of the steam exceeds the temperature of the boiling point corresponding to the pressure which is under consideration. For practical purposes the number of degrees of superheat present is usually determined by ascertaining the actual temperature of the steam by a thermometer and deducting the temperature of saturated steam for the given pressure, as found from the steam table. Thus, if the gage pressure of the steam is 150 lb. per sq.in. and a thermometer inserted in it shows that its temperature is 470 deg. F., then, as the temperature of saturated steam for the pressure is about 366 deg. F., there would be

$$470 - 366 = 104 \text{ deg. of superheat.}$$

Relative Economies of Evaporation—If, with an average temperature of feed water of 44.4 deg. F., a boiler evaporates 36,315 lb. of water into dry saturated steam at an average gage pressure of 110.4 lb. per sq.in., using 5326 lb. of coal, what would be the relative economy with an evaporation of 39,000 lb. of water from a feed temperature of 45 deg. F. into dry saturated steam at an average gage pressure of 107.6 lb. per sq.in. and using 5600 lb. of coal, the kind of coal, duration of trials and other conditions being the same?

M. T. J.

In the first instance the actual evaporation would be 36,315 ÷ 5326 = 6.818 lb. of water per pound of coal. A pound (weight) of steam at 110.4 lb. gage pressure or about 125 lb. absolute contains 1190.3 B.t.u. above 32 deg. F., and as each pounds of feed water at 44 deg. F. contains 44.4 — 32 = 12.4 B.t.u. above 32 deg. F., the heat received by each pound of water evaporated would be

$$1190.3 - 12.4 = 1177.9 \text{ B.t.u.}$$

As the heat required for evaporation of a pound of water from and at 212 deg. F. is 970.4 B.t.u., the factor of evaporation would be

$$1177.9 \div 970.4 = 1.2138$$

so that the evaporation of 6.818 lb. of water per pound of coal would, under the conditions, be equivalent to the evaporation of

$$6.818 \times 1.2138 = 8.2757 \text{ lb.}$$

of water from and at 212 deg. F. per pound of coal.

In the second instance the actual evaporation would be 39,000 ÷ 5600 = 6.964 lb. of water per pound of coal. As the gage pressure of 107.6 lb. per sq.in. would be equal to about 122 lb. absolute, each pound (weight) of steam would contain 1189.8 B.t.u. above 32 deg. F. With feed water at 45 deg. F. each pound evaporated into steam would receive

$$1189.8 - (45 - 32) = 1176.8 \text{ B.t.u.}$$

the factor of evaporation would be

$$1176.8 \div 970.4 = 1.2132$$

and there would be an evaporation equivalent to

$$6.964 \times 1.2132 = 8.4487 \text{ lb. of water per pound of coal.}$$

Therefore, in the second instance there would be

$$\frac{8.4487 - 8.2757}{8.2757} \times 100 = 2.09 \text{ per cent.}$$

more water evaporated per pound of coal, and for evaporation of the same quantity of water the percentage less of coal would be

$$\left(\frac{1}{8.2757} - \frac{1}{8.4487}\right) \times 100 \times 8.2757 = \text{nearly } 2.05 \text{ per cent.}$$

Such small variations of conditions would be required to make the evaporative economies equal that, for all practical purposes, the results may be regarded as identical.

[Correspondents sending us inquiries should sign their communications with full names and post-office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

License Legislation in the United States*

By A. A. Potter†

Thirty-four states have no state laws at present and no proposed state legislation for licensing stationary engineers. They are: Alabama, Arizona, Arkansas, Colorado, Connecticut, Florida, Georgia, Idaho, Iowa, Kentucky, Louisiana, Maine, Maryland, Michigan, Mississippi, Missouri, Nebraska, New Hampshire, New Mexico, New York, North Carolina, North Dakota, Tennessee, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin and Wyoming.

Nine states—California, Delaware, Illinois, Indiana, Kansas, Minnesota, Pennsylvania, Rhode Island and Texas—had laws pending in 1915. Charles H. Wirmel, chairman of the N. A. S. E. License Committee, asserted that a state law is pending in Washington. I have been unable to secure from the secretary of state at Washington any confirmation that such a law is before their legislature.

In Indiana an attempt has been made several times to have a state license law passed, but without success. The manufacturers, farmers, and even many of the operating engineers fought the bills introduced.

Several unsuccessful efforts were made to enact a state law in Missouri, but nothing was brought up at the 1915 session of the legislature. The State of New Hampshire has certain laws regarding engineers operating steamboats.

North Dakota, in Sec. 8994 of the 1905 Revised Codes, holds the engineer or other person having charge of steam boilers and engines responsible and guilty of a misdemeanor for accidents whereby human life is endangered.

The states having city laws include Alabama, California, Colorado, Connecticut, Indiana, Iowa, Illinois, Louisiana, Maryland, Michigan, Nebraska, New Jersey, New York, Pennsylvania, Tennessee, Washington and Wisconsin. These laws were given in detail in the "Report of the License Committee of the N. A. S. E." in 1906.

The act of the general assembly of the State of Louisiana empowers municipalities of over 50,000 inhabitants, through their local councils, to regulate the use of stationary and portable steam boilers, and to constitute and appoint a board of examiners of stationary and portable steam-boiler engineers for the carrying out of this purpose . . . empowers said municipalities to require persons operating steam boilers . . . , to have in their possession and posted in conspicuous places in the engine room where employed as such, certificates of authority . . . This act further requires owners to have none but certified engineers, having proper certificates and renewals thereof.

Missouri has at present the following law: "No person is authorized to manage, control or take charge of or act as engineer of any steam boiler, engine or apparatus, who has not the requisite knowledge or ability to manage the same with safety to the lives and property of the inhabitants of such cities. Any incorporated association of qualified local steam engineers in any city is authorized to appoint an examining committee for the granting of certificates of qualifications." Provision is also made that no charge exceeding one dollar is to be made for any certificate.

The State of Maine has certain laws pertaining to school buildings, churches or other public buildings when heated by a steam plant located in, under or near such building.

EXISTING AND PROPOSED LAWS

Examiners—The state license laws are under the jurisdiction of the boiler-inspection department of the District Police in Massachusetts. In Montana the state boiler inspectors attend to the licensing of engineers. In Nevada the boards of county examiners regulate the operation of stationary and hoisting engines. The state laws of Nevada are not very extensive or definite, but aid in protecting life and property. The district examiners, who are under the Industrial Commission of Ohio, examine applicants for licenses, while in New Jersey this power is vested in a bureau of the Department of Labor, known as the "Steam Engine and Boiler Operators' License Bureau." In Minnesota 53 inspectors are appointed by the governor and these examine engineers, issue licenses and inspect boilers. This system makes it possible to build up quite a political patronage. A new bill has been introduced into both branches of the Minnesota legislature this year which is indorsed by the Minnesota State Association of the N. A. S. E., the main features of which will be brought out later.

Among the states having proposed state license laws in 1915, California, Illinois and Pennsylvania have an examining board consisting of one chief engineer and several assistant examiners. In Indiana an examining board is appointed by the governor, but this board is under the supervision of the chief inspector of the State Bureau of Inspection, who is ex-officio the president of the examining board. In California the examining board is appointed by the commissioners of the Bureau of Labor Statistics. In Minnesota and Texas one examiner is appointed for each congressional district. The contents of the bills for Delaware and Rhode Island could not be secured. The proposed state law of Kansas vested the licensing power in an "Engineers License Committee."

In the majority of states a person to be eligible as examiner must have ten to fifteen years of practical experience.

License Required—Those exempted from license requirements include operators of locomotives, motor road vehicles, boilers in private residences, boilers and engines under the jurisdiction of the Government of the United States, boilers carrying not more than 15 lb. pressure, boilers and engines (stationary and traction) when used for agricultural purposes exclusively.

In Illinois and New Jersey the exemptions include boilers carrying not more than 10 lb. pressure and in Illinois only heating plants which serve 50,000 sq.ft. radiation or less. In California boilers less than 4 hp. and also those used in logging camps or in pumping or boring wells for oil or water are exempted. The proposed bill of Indiana and Ohio exempts boilers used in the production of crude oil. In some states the existing or proposed laws exempt only such heating boilers as are provided with a device approved by examiners, limiting the pressure to 15 lb. Apartment houses to be exempt must have less than five flats. In several states fire-department engines are exempt.

The exemption limit for boilers and engines is 9 hp. in Massachusetts, 30 hp. in Ohio and Pennsylvania, and 250 hp. in Texas. In Texas this high limit is fixed in order to exempt all ginners, contractors and sawmills of the state. In Pennsylvania first- and second-class cities are exempt from the state license act, such cities having municipal license laws.

Classification of Licenses—Several of the proposed bills seem to be in favor of making no differentiation between grades or classes of engineers. California, Indiana, Illinois, Nevada, New Jersey and Pennsylvania have such bills in force or proposed. A large number of the cities of the first class have unclassified license laws, the opinion being that the license law is mainly for the protection of life and property.

The Massachusetts license law includes four different classes of engineers' licenses, three classes of firemen's licenses and a special license for particular plants.

The proposed law of Minnesota calls for four classes of engineers' licenses and also a special license for portable, traction or agricultural engines.

In Montana there are three classes of engineers' licenses and a traction-engine license. Firemen not under the direct charge of an engineer are required to have a third-class license.

Ohio classifies engineers' licenses into first, second and third grades. These licenses are granted partly upon the percentages received in the examination, as will be explained in the next section.

The Texas bill grades engineers into three classes—first, second, and special. The owner or lessee is held responsible for the engineer carrying a special license.

The proposed Kansas bill provided for two grades of engineers' licenses.

Requirements for Licenses—All proposed state bills make provision for issuing licenses to engineers engaged in the practice of their occupation at the time the licensing act takes effect.

In Massachusetts where the licenses are classified, to be eligible for a first-class fireman's license a person must have been employed as a steam engineer or fireman in charge of or operating boilers for not less than one year. The third-class engineer's license requires one and one-half years' ex-

*Paper presented before the Kansas State Convention of the National Association of Stationary Engineers at Wichita, on May 14, 1915.

†Dean of the Division of Engineering and Professor of Steam and Gas Engineering at the Kansas State Agricultural College.

perience, the second-class engineer's license two years' experience in a plant having at least one engine of over 50 horsepower. A person who has served an apprenticeship for three years to the machinist or boiler-making trade or is a graduate of a recognized engineering college, is eligible to take the second-class engineer's examination if he has been employed for one year in connection with the operation of a steam plant. Three years' experience in a power plant having at least one engine of 150 horsepower is the requirement for first-class license examination.

The proposed act of Minnesota requires five years' experience for first-class license, three years' experience for second-class, and one year's experience for third-class license.

In Montana the requirements are three years' experience for first-class license, two years' experience for second-class license, and one year's experience for third-class license.

In Ohio a first-class license is granted to applicants who have had three years' practical experience and who obtain a percentage of 85 or more in the examination. Two years' experience and a percentage rating of from 70 to 84 entitle the applicant to a second-class license, while the third-grade applicant must have one year's experience and an examination rating of from 60 to 69.

No definite requirements were outlined for the two grades of licenses in the proposed Kansas bill.

A clause should appear in bills or acts giving special authority to representatives or erecting engineers of any manufacturers of boilers or engines when employed in installing, testing, or operating boilers or engines.

Fees for Licenses—Illinois and Ohio, $2 for license and $2 for yearly renewal. California, Nevada and Texas charge $5 for license. Nevada has no renewal requirement, while California and Texas charge annual renewal fees of $2 and $5 respectively. The proposed law of Pennsylvania has $3 for license and $1 for renewal. In Montana the charges are: $7.50 for first-class license, $5 for second-class, $3 for third-class and special, and $1 for yearly renewal for all grades. The proposed Kansas law provided for $5 fee in the case of first-class license, $3 for second-class, and yearly renewal charges for the two classes $3 and $2 respectively.

The present Minnesota law allows the inspector to grant licenses for a fee of $1, which he pockets. The proposed law includes $2 for examination and $1 for annual renewal.

Appeal from Refusal of License—A person who is aggrieved by the action of an examiner in refusing or revoking a license has the right of appeal therefrom in all states except in Massachusetts, where the action of the examining board is final. In several states the applicant has the privilege of having one outside person during the examination or during the hearing of an appeal. This person is not allowed to take part, but can take notes if he so desires.

Posting of License—In the majority of states the act requires that the engineer's or the firemen's license be placed in a conspicuous position in the engine room of the plant operated by the holder of such license.

Operation without License—In Massachusetts a person without a license is allowed to operate a plant for one week, in Pennsylvania ten days and in Montana for a period of fifteen days, provided notice to that effect is sent to the inspector. In the majority of cases no provision is made authorizing operation without license.

Records of Operation—The Massachusetts law requires "a daily record of the boiler, its condition when under steam and all repairs made and work done on it" upon regular printed forms furnished by the boiler-inspection department.

Boiler Inspection—The states of Colorado, Connecticut, Massachusetts, Minnesota, Montana, Nevada, New York, Ohio, Pennsylvania and Wisconsin have boiler-inspection laws. In Colorado the governor appoints a chief and three deputy boiler inspectors who test every stationary boiler annually. The same is the case in Connecticut, where a boiler inspector is appointed from each congressional district.

In Massachusetts and in Ohio, besides the boiler-inspection department, which is responsible for the inspection of boilers, there is a "Board of Boiler Rules." The chief inspector of the boiler-inspection department is the chairman of the board of boiler rules, the other members being selected to represent the boiler-using interests, the boiler-manufacturing interests, the boiler-insurance interests and the operating engineers. The board of boiler rules formulates rules for constructing, inspecting, installing and testing of boilers.

Montana seems to have had boiler-inspection laws for many years. The 13th Biennial Report of the state boiler inspector shows that even in such a large and thinly populated state as Montana the boiler-inspection department has not only been self-sustaining, but has produced a revenue for the state, over all expenses, of nearly $16,000. The state has no record of a serious boiler explosion.

In New York the state fire marshal has charge of boiler inspection.

[This office has been discontinued and the duties of boiler inspection transferred to the factory inspector.—Editor.]

In Wisconsin boiler inspection is under the Industrial Commission, which has a standard code of rules for the construction, operation and inspection of boilers. This commission accepts inspections from qualified inspectors in cities of the first, second, and third class.

The fees for boiler inspection are, in the majority of states, $5 for external and internal inspection of each boiler and $2 when the boiler is only externally inspected under steam pressure. In Connecticut provision is made for inspecting steam boilers owned by farmers, once in two years for a fee of $2, provided such boilers do not exceed 5 hp. each. In Montana a charge of $10 is made for the inspection of a single boiler and $5 for each additional boiler.

The present law of Minnesota allows the inspectors to charge $3 for each boiler inspection and to keep such fees. The proposed law of Minnesota places a fee of $3 for the inspection of a single boiler and $2 for the inspection of each additional boiler.

In this connection the recent act before the 1915 Pennsylvania legislative session is of some interest. This act requires municipal inspection of steam and hot-water installations and provides for the examination, licensing and registration of persons, firms or corporations engaged in the business or work of steam and hot-water fitting.

DISPOSITION OF 1915 BILLS

It may be of interest to report the status of the bills proposed in 1915: The Kansas bill was killed in the committee. The Delaware, California, and Rhode Island bills were lost. The proposed license-law bill of Pennsylvania was declared unconstitutional by the attorney-general, principally on account of its exemptions. An act for the licensing of engineers in third-class cities of Pennsylvania passed through the committee and it is understood has a good chance of passing the House. In accordance with this bill, the city council appoints an examining board, consisting of two engineers who have had not less than six years' practical experience, to act in conjunction with the director of public safety. The proposed engineers' license and boiler-inspection law of Minnesota was defeated in the Senate on Feb. 18, after much hard and creditable work on the part of the Minnesota State Association of the N. A. S. E. No definite information could be secured regarding the ultimate fate of the bills proposed in Illinois, Indiana and Texas.

Powdered Coal

At the seventh annual convention of the International Railway Fuel Association, W. L. Robinson, supervisor of fuel consumption of the Baltimore & Ohio R.R., read an interesting paper outlining the advantages that might result from the use of powdered coal in locomotive furnaces. The cost of fuel for the 65,000 steam locomotives in use in the United States is from $250,000,000 to $275,000,000 per annum, and now represents about 25 per cent. of the total transportation-account expenses. The fuel used is principally bituminous coal, anthracite, fuel-oil, lignite and coke. While powdered coal has been used successfully and rather extensively for years in cement and metallurgical furnaces, its use for steam-making purposes has been limited, owing to the lack of practical development. Its possibilities, however, are great, and if the practical difficulties can be overcome, the saving for the various railroad companies throughout the country will be on a corresponding scale.

Coal in a finely divided or powdered state represents the most advanced method for producing perfect combustion. While a cubic inch of solid coal exposes only 6 sq.in. for absorption and liberation of heat, a cubic inch of powdered coal exposes from 20 to 25 sq.ft., which enables the more uniform gas production from the volatile matter in the coal and the more prompt and perfect intermingling of gas and air, thereby improving combustion and reducing smoke. Furthermore, there is no cooling of the fire by heavy intermittent charges of fresh coal, as is the case with hand or stoker firing on grates.

It has been generally thought that for the burning of solid fuels in powdered form in suspension, a bituminous coal of less than 30 per cent. volatile matter could not be used with satisfactory results. Mr. Robinson, however, had been informed that good results were being obtained in locomotive practice from semibituminous coal analyzing as low as 21 per cent. volatile and having 15 per cent. ash and moisture. To give the best general results and the least trouble from ash and slag, powdered coal should contain not more than 1 per cent. moisture and be of a uniform fineness, so that not less than 95 per cent. will pass through a 100-mesh, not less than 85 per cent through a 200-mesh, and not less than 70 per cent. through a 300-mesh screen.

COST OF POWDERING

The cost of preparing powdered coal will vary with the cost for the raw coal and its moisture content. However, a general average from available data covering periods of the past five to ten years at cement and metallurgical plants has made it possible to present the following conservative estimate, assuming the cost of the raw coal at from $1 to $2 per short ton, and that it will require crushing and have a moisture content of from 5 to 10 per cent. when placed in the drier:

Capacity of Plant in Short Tons per Hour	Average Total Cost for Preparation per Short Ton
2	From 25 to 50 cents
3	From 20 to 45 cents
4	From 16 to 40 cents
5	From 14 to 35 cents
10	From 12 to 30 cents
25	From 10 to 20 cents

The fuel required for drying the coal will average from 1 to 2 per cent. of the coal dried. The distribution of the total may be approximately stated as follows:

Fuel for drying	10 per cent.
Power for operation	30 per cent.
Labor	30 per cent.
Maintenance and supplies	25 per cent.
Interest, taxes, insurance and depreciation	5 per cent.
Total	100 per cent.

The cost of preparing powdered coal should be more than offset by the ability to utilize mine refuse and sweepings, run-of-mine, screenings and slack grades of coal that cannot be used to good advantage otherwise, and inferior grades of sub-bituminous coals, lignite and peat of relatively lower cost per ton than the readily salable commercial fuels.

Powdered coal may be burned by either of two generally defined methods—the long-flame method, constituting a progressive burning of the coal such as is employed in cement and openhearth furnaces, and the short-flame method, which is the latest development and is used in metallurgical and similar metal-heating work or under boilers where a similar furnace volume obtains. A combination of the long- and short-flame methods has been tried recently on a New York Central locomotive equipped for burning powdered coal.

LOCOMOTIVE MODIFICATIONS REQUIRED

For locomotive work the principal requirements are an inclosed fuel container, means for conveying the fuel to the feeders, means for commingling the fuel with air at the time of feeding, and afterward equipment for supplying the proper amount of air to produce a combustible mixture at the time the fuel and air finally enter the furnace, a suitable refractory-material furnace in the firebox, means for disposing of the slag, means for producing the proper draft through the furnace and boiler, means for harmonizing the draft and the combustion, suitable power for operating the fuel- and air-feeding mechanism, and automatic and hand control of the fuel and air regulation.

It is understood that the developed equipment for burning pulverized fuel can be readily applied to all existing modern types of steam locomotive without any changes in the boiler except to install arch brick supporting tubes, where fireboxes are not now equipped, and to remove the grates, ashpan and smokebox draft appliances. There is no equipment in the cab except the automatic hand control, which is placed in a position convenient to the fireman. The inclosed fuel container is suitable for either powdered coal or fuel oil and either kind of fuel can be used by changing the feeding equipment. The total weight of equipment applied will about equal that of the equipment removed. When not in operation the necessary draft through the boiler is obtained by the usual stack steam blower, and by exhaust steam from the cylinders when the locomotive is working. The supply of fuel is regulated according to the work the locomotive is performing, and when drifting or standing on sidings or at terminals, it can be entirely shut off. The exhaust-nozzle opening is about double the area of that used for grate firing.

Some of the advantages enumerated were the sustained boiler horsepower obtained from the use of powdered coal, the ability to increase the economical length of run, the firing of the boilers automatically with no hand-labor, the prevention of cinders, sparks, and smoke; the reduction in cylinder back-pressure due to the enlarged exhaust passages; saving in inspection, maintenance and operation through the elimination of grates, ashpans, dampers, etc.; a more uniform furnace temperature, reducing the liability of firebox and flue leakage; ability to make use of inferior qualities and grades of solid fuel; reduction of delay from cleaning or dumping fires; and a number of other factors which would tend to improve efficiency and lower the cost per car-mile.

DISCUSSION OF THE PAPER

The paper aroused a great deal of interest, and the subject was considered of enough importance to appoint a permanent committee to keep posted on developments in this field. In the discussion some of the difficulties experienced in burning powdered coal were brought to light. The principal objection and the most serious factor interfering with the continuous operation of the locomotive was the formation of large quantities of slag, which clings to the boiler plates, fills up the tubes and forms on the superheating surface. E. H. Stroud, a maker of powdered-coal equipment, who has had considerable experience in an experimental stationary plant equipped for burning powdered fuel, explained that there were several essential factors which must be given attention to burn this coal successfully. First, it is necessary to powder the coal to the proper fineness. This is vital, because instantaneous ignition within a few inches of the burner must be obtained. Unless complete combustion is obtained at once, slag will form. The furnace must get the proper amount of air, and to insure a correct mixture mechanical means to measure the coal and air are required. Slag was an objectionable feature, but there is no occasion to permit it to get as far as the boiler tubes. All of this could be precipitated in a chamber formed by a specially constructed arch at the rear of the firebox. It was his conviction that it paid to dry the coal. This could be done while it was being pulverized. The cost of pulverizing, including power, wear and tear and attendance, at a rate of 5 to 10 tons per hour, should not exceed 15c. per ton. Drying would add 4 to 6c. per ton. As to a capacity of individual units, burners could be made which would burn as low as 15 lb. per hour and as high as 5000 lb. per hr.

Joseph Harrington, who has recently become associated with the Powdered Coal Engineering & Equipment Co., of Chicago, discussed the question from the standpoint of smoke abatment. In Chicago and many other municipalities electrification has been urged because it eliminates smoke, soot, cinders, sparks and excessive noise. Within the City of Chicago alone the cost to electrify the railroads has been estimated at $190,000,000. It would appear that the same results can be obtained by the use of powdered coal, at a cost which would be insignificant in comparison. A uniform system would be maintained on the railroads and according to an estimate by Mr. Robinson, the use of powdered coal would result in a saving on various heat losses alone of 25 per cent. This does not include savings from the prevention of smoke, soot, cinders, sparks, ash-handling, the use of inferior grades of soft coal, elimination of smoke inspectors, which in Chicago alone costs the railroads $65,000 per annum, and the solution of other problems that enter into the production of steam power in locomotives.

Potential Hydro-Electric Development in Ontario, Canada

It is conservatively estimated that within a radius of fifty miles from Ottawa, there is available water power of approximately one million horsepower. The Ottawa River alone would supply 700,000, and its tributaries 300,000 horsepower. This estimate is based upon an average of water obtainable throughout the year from twelve to fourteen rivers. In this section are many great lakes that can be converted into immense reservoirs. A number of dams have been built on the upper reaches of the Ottawa River, insuring when fully completed a steady supply of water throughout the year.

Eminent authorities, when calculating the relative cost of hydro-electric and steam-generated energy, place the latter on the basis of $25 per horsepower year. Estimating the cost of the same power generated by water at $10 yearly, the saving effected for an output of one million horsepower would be fifteen million dollars. This power is all within a short distance of Ottawa, and therefore can be transmitted to that city very economically. The accompanying table was prepared by Holgate, McDougall and Ker, well-known civil and hydraulic engineers, acting as a special commission for the City of Ottawa. The data relate to existing installations within thirty miles of the city.

Name of Power Site	Distance (Miles) of Trans.	Hp. Output of Sub-station	Cost per Hp. per Year
Metropolitan Company	7	5,100	15.73
Metropolitan Company	7	11,050	13.89
Gatineau River	7	5,000	13.60
Gatineau River	7	10,000	8.80
Gatineau River	7	20,000	6.50
Lievre River	30	5,000	13.95
Lievre River	30	10,000	9.13

Lievre River	30	20,000	6.99
Lievre River	30	30,000	6.06
Chats Falls	30	5,000	13.20
Chats Falls	30	10,000	9.20
Chats Falls	30	20,000	7.80

Another section offering a splendid opening for enterprising capitalists to develop and exploit its water powers and industrial resources is the Sault Ste. Marie district. The Canadian share of the great falls on the "Soo" is yet undeveloped, while with the several falls on the Michipocoten River and the Steep Hill Falls on the Magpie River, there is easily 100,000 horsepower in the immediate vicinity. In the district to the north, millions of dollars worth of iron and other natural resources, the great spruce forests of the clay belt and an unlimited pulpwood area are awaiting development.

Committee on Classification of Technical Literature

Delegates from about twenty national technical and scientific societies met at the Engineering Societies Building, New York, on May 21 to perfect a permanent organization, the purpose being to prepare a classification of the literature of applied science which might be generally accepted and adopted by these and other organizations. It was the feeling of the meeting that such a classification, if properly prepared, might serve as a basis for the filing of clippings, for cards in a card index, and for printed indexes; and that the publishers of technical periodicals might be induced to print against each important article the symbol of the appropriate class, so that a file might be easily made which would combine clippings, trade catalogs, maps, drawings, blueprints, photographs, pamphlets, and letters, classified by the same system.

By request, W. P. Cutter, librarian of the Engineering Society's Library, read a paper on "The Classification of Applied Science," and after describing the existing classifications, stated that in his opinion no one of these was worthy of general adoption. He outlined a plan whereby a central office could collect all the existing classifications and with the help of the various national societies interested might compile a general system which, although not absolutely perfect, might be generally accepted.

The following societies were represented by delegates: United Engineering Society, American Foundrymen's Association, Society for Electrical Development, American Ceramic Society, American Institute of Architects, American Society of Agricultural Engineers, American Society of Refrigerating Engineers, American Gas Institute, American Water-Works Association, American Society of Mechanical Engineers, National Fire-Protection Association, American Society of Heating and Ventilating Engineers, Society of Automobile Engineers, Society for the Promotion of Engineering Education, United States Bureau of Standards, American Physical Society, Franklin Institute, American Institute of Mining Engineers, American Society for Testing Materials, National Electric Light Association, American Electro-Chemical Society, Illuminating Engineering Society, and American Railway Engineering Association.

The name adopted for this organization is "Joint Committee on Classification of Technical Literature." A permanent organization was effected by the election of the following executive committee: Fred R. Low, chairman; W. P. Cutter, 29 West 39th St., New York, secretary; Edgar Marburg, H. W. Peck and Samuel Sheldon.

Meeting of Engineering Foundation

The Engineering Foundation held its first regular meeting May 25, and selected a board to administer the trust founded by Ambrose Swasey, as described in our Feb. 2 issue. The board consists of Charles Warren Hunt and J. Waldo Smith, representing the American Society of Civil Engineers; Dr. Alexander C. Humphreys and Jesse M. Smith, American Society of Mechanical Engineers; Dr. A. R. Ledoux and Benjamin D. Thayer, American Institute of Mining Engineers; Charles E. Scribner and Dr. M. I. Pupin, American Institute of Electrical Engineers; Edward D. Adams and Howard Elliott, representing the general public. The officers elected were: Gano Dunn, chairman, by virtue of his office as president of the United Engineering Society; Edward D. Adams, vice-chairman; F. R. Hutton, secretary, and Joseph Struthers, treasurer.

A large number of applications have already been received from those who want to use the funds for research work. Because of the number of applications and the incomplete form in which many of them were received, a schedule of requirements for applicants is being prepared by the following committee, which was chosen by the board: Dr. A. R. Ledoux, chairman; J. Waldo Smith, Dr. M. I. Pupin and Dr. Alexander C. Humphreys.

Recent Court Decisions

Digested by A. L. H. STREET

Spread of Fire by Portable Engines—The law enacted by the Wisconsin Legislature in 1913, requiring traction and portable engines to be equipped with a "screen or wire netting on top of the smoke-stack and so constructed as to give the most practicable protection against the escape of sparks and cinders" and "with the most practicable devices to prevent the escape of fire from ashpans or fireboxes," has just been considered by the Supreme Court of the state in the case of Legro vs. Carley, 150 "Northwestern Reporter," 985. The court holds that the statute is sufficiently specific in its requirements to be valid, and that a spark arrester in a threshing machine, consisting of an inverted cone of screen wire, is not a sufficient spark arrester, if it has been permitted to remain unrepaired after the point of the apex has burned or rusted off.

Effect of Temporary Use of Gasoline Engine on Fire Risk—A clause in a fire policy reading, "This policy shall be void . . . if camphene, benzine, naptha or other chemical oils or burning fluids shall be kept or used by the insured, on the premises insured," does not invalidate the policy on account of the temporary use of a gasoline engine, especially where the insurance company must have contemplated such use of the engine. This is the holding of the Maine Supreme Judicial Court in the case of Bouchard vs. Dirigo Mutual Fire Insurance Co., 92 "Atlantic Reporter," 899. It appears that the defendant company issued to the plaintiff a policy containing the clause quoted, covering a farm house and barn, and denied liability for a loss because it resulted from using a gasoline engine in driving threshing machinery. But the court held that such use must have been contemplated when the policy was issued, and that the clause mentioned must be construed as applying to some permanent condition increasing the fire risk, and not to mere temporary use of a gasoline engine.

Responsibility for Employee's Negligence—The owner of a power plant is not liable for injury to a boiler company's inspector, resulting from negligence of an engineer employed by the owner, if, in undertaking to assist in the inspection, the engineer exceeded his authority. This, in effect, is the decision of the Illinois Supreme Court lately announced in the case of Johanson vs. Wm. Johnston Printing Co., 104 "Northeastern Reporter," 1046. The evidence showed that the boiler company was employed to inspect the boiler, which had been leaking, and sent the plaintiff to do the work. He went into the combustion chamber of the boiler, the fire having been drawn, and was scalded through leaking of hot water upon him. In his suit to recover for the injury, he relied upon the engineer's negligent failure to remain near the boiler as he had promised to do. The Supreme Court disposed of the case in the defendant's favor on the ground that the engineer was not authorized to assist in the inspection, and acted beyond the scope of his duties in so doing. The court said: "Outside of the scope of his employment, the servant is as much a stranger to the master as any third person, and an act of the servant not done in the execution of services for which he was engaged cannot be regarded as the act of the master."

Make Dinkel Steam Trap—We are informed by the Schütte & Koerting Co., Twelfth and Thompson Streets, Philadelphia, Penn., that they also manufacture the Dinkel steam trap, a description of which was published on page 644 of the May 11 issue.

At a Meeting of the American Physical Society, Prof. C. W. Chamberlain, of Denison University, Granville, Ohio, presented and demonstrated his compound interferometer, by which it is possible to measure 0.00000005 of an inch. It is next to impossible for the human mind to conceive the minuteness of a measurement of this kind. It is equal to the apparent size of the head of an ordinary pin viewed at a distance of 227 mi. or the size of a silver dollar viewed at a distance of 9000 miles. —"American Machinist."

ENGINEERING AFFAIRS

The Association of Iron & Steel Electrical Engineers will hold its annual convention at the Hotel Statler, Detroit, Mich., Sept. 8-11. Suggestions regarding arrangements and inquiries regarding accommodations should be addressed to A. H. Swartz, Chairman Convention Committee, Churchill Ave., Cleveland, Ohio.

The American Society of Civil Engineers has adopted resolutions providing that its representatives shall confer with the Federal authorities on the plan by which a reserve corps of army engineers shall be developed from its membership. The resolutions state that these men are not only seasoned in all lines of organization and constructive work, but are also closely in touch with the best workers from whom the rank and file of all branches of military service can be drawn. A committee has been appointed to take up with the War Department the plan of organizing this corps.

International Engineering Congress—The materials of engineering construction will receive special attention in the proceedings and discussions of the International Engineering Congress to be held in San Francisco, Sept. 20-25. The field will be treated under 18 or more topics, covering: Timber resources; preservative methods; brick and clay products in general; life of concrete structures; aggregates for concrete; waterproofing; volume changes in concrete; world's supply of iron; life of iron and steel structures; special steels; status of copper and world's supply; alloys; aluminum; testing of metals, of full-sized members, and of structures. These papers, with discussions, will be published as Volume 5 of the "Transactions," and will be illustrated. For full particulars apply to W. A. Cattell, secretary, 417 Foxcroft Building, San Francisco, Calif.

NEW PUBLICATIONS

MATERIALS OF MACHINES—By Albert W. Smith, Director of Sibley College, Cornell University. Published by John Wiley & Sons, Inc., New York. Size, 5x7 in.; 215 pages; 36 diagrams. Price, $1.25.

In the second edition, which has been entirely rewritten and considerably enlarged, Professor Smith's little book gives an elementary view of the manufacture and properties of iron, steel, copper, lead, tin, zinc, aluminum and the brass and bronze alloys. The first part of the book gives a brief outline of the metallurgy of the materials. It also takes up fuel combustion, the types of electric furnaces and the refractory materials used in lining metallurgical furnaces. The second part relates to chemical and mechanical properties, and includes chapters on testing materials, on the heat treatment of steel, and on brass and bronze alloys. The book is self-contained and the reader need not consult chemistries, metallurgies and works on strength of materials in order to use the information.

VOCATIONAL MATHEMATICS—By William H. Dooley, Principal of Technical High School, Fall River, Mass. Published by D. C. Heath & Co., New York. Size, 5x7 in.; 341 pages; illustrated. Price, $1.

The author has prepared this book for use in vocational schools, in which it is necessary to impress students with the direct application of their mathematical knowledge to trade and industry. After a review of the essentials of arithmetic and mensuration, problems peculiar to the carpenter, plumber, steam engineer, electrician, machinist and to the sheet-metal and textile worker are presented. To illustrate the method followed, the chapter devoted to engines contains an illustrated description of simple vertical and horizontal engines, of the indicator, methods of calculating horsepower, mean effective pressure from indicator cards, flywheel weight, steam lap and size of supply pipes. Of course, the derivation of the formulas is not given, but their application and problems relating to them are given. Much of the technical information has no bearing on mathematics, and in addition is not always correct. Such errors as the expression of latent heat in degrees and the labeling of a series as a parallel circuit should have been avoided.

PUBLICATIONS OF THE BUREAU OF MINES

Bulletin 88: The Condensation of Gasoline from Natural Gas. By G. A. Burrell, F. M. Seibert, and G. G. Oberfell; 1915; 106 pp., 6 pls., 18 Figs.

Technical Paper 101: Permissible Explosion-Proof Electric Motors for Mines; Conditions of Tests and Requirements for Test and Approval. By H. H. Clark; 1915; 17 pp., 2 pls., 1 Fig.

A limited supply of these papers is available for distribution to those interested. They should be ordered by number and title from the Director of the Bureau of Mines, Washington, D. C.

TRADE CATALOGS

Dodge Sales and Engineering Co., Mishawaka, Ind. Catalog. Gearing. Illustrated, 126 pp., 6x9 in.

B. F. Sturtevant Co., Hyde Park, Boston, Mass. Bulletin No. 218. Vertical engines. Illustrated, 16 pp., 6½x9 in.

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn. Bulletin C. A. Simplex-Caskey valves for hydraulic service. Illustrated, 4 pp., 6x9 in.

Link-Belt Co., Philadelphia, Penn. Book No. 210. Wagon and truck loaders for handling coal, coke, stone, sand, etc. Illustrated, 48 pp., 6x9 in.

SKF Ball Bearing Co., 50 Church St., New York. Bulletin No. 25. SKF Ball bearings in machine tools and shop equipments. Illustrated, 68 pp., 6x9 in.

Smooth-On Mfg. Co., 572-74 Communipaw Ave., Jersey City, N. J. Pamphlet No. 4. Smooth-On Iron Cement No. 7 for water-proofing brick ad concrete construction. Illustrated, 4 pp., 6x9 in.

The Jeffrey Mfg. Co., Columbus, Ohio. Bulletin No. 165. Wagon and truck loaders for sand, gravel, etc. Illustrated, 16 pp., 6x9 in. Bulletin No. 166. Wagon and truck loaders for bituminous and anthracite coal. Illustrated, 24 pp., 6x9 in.

BUSINESS ITEMS

The American Pin Co., of Waterbury, Conn., has recently ordered from the Builders Iron Foundry, Providence, R. I., one large meter tube for boiler feed service. The Imperial Tobacco Co., of Montreal, Canada., has also ordered a 2-in. meter tube for the same service.

The Cooling Tower Co., with headquarters at No. 50 Broad St., New York, has been incorporated to handle the growing demand for the well-known "Mitchell-Tappen" cooling towers, the patents on which are now controlled by the new company, which also has additional patents pending. The operations of the company will not be confined to cooling towers alone but where the purchasers' manufacturing conditions warrant it the new company is prepared to design and install spray-nozzle systems and other cooling devices for the economical re-cooling of liquids from all forms of condensing, refrigerating, smelting or gas engine plants.

Classified Ads

Positions Wanted, 3 cents a word, minimum charge 50c. an insertion, in advance

Positions Open, (Civil Service Examinations), **Employment Agencies (Labor Bureaus), Business Opportunities, Wanted (Agents and Salesmen—Contract Work), Miscellaneous** (Educational—Books), **For Sale, 5 cents a word, minimum charge, $1.00 an insertion.**

Count three words for keyed address care of New York: four for Chicago Abbreviated words or symbols count as full words.

Copy should reach us not later than 10 A M. Tuesday for ensuing week's issue Answers addressed to our care, Tenth Ave. at Thirty-sixth Street, New York or 1144 Monadnock Block, Chicago will be forwarded (excepting circulars or similar literature).

No information given by us regarding keyed advertiser's name or address.

Original letters of recommendation or other papers of value should not be inclosed to unknown correspondents. Send copies.

Advertisements calling for bids, $3.60 an inch per insertion. P

POSITIONS OPEN

MAN to sell heavily advertised power-plant specialties in New York; must have knowledge of power-plant equipment; an engineer will be considered; position permanent to right man with old-established house. Write full particulars, giving salary desired and past connections. P. 518, Power.

POSITIONS WANTED

ENGINEER, experienced in alternating and direct motors and generators, engines, turbines and ice machines; A-1 references. P. W. 521, Power.

CHIEF ENGINEER, employed in central station; seven years' experience with engines, turbines, dynamos, boilers; married; age 30. P. W. 511, Power, Chicago.

TECHNICAL GRADUATE, Middle West university, mechanical engineering, two years' practical experience, desires position with progressive firm. P. W. 524, Power.

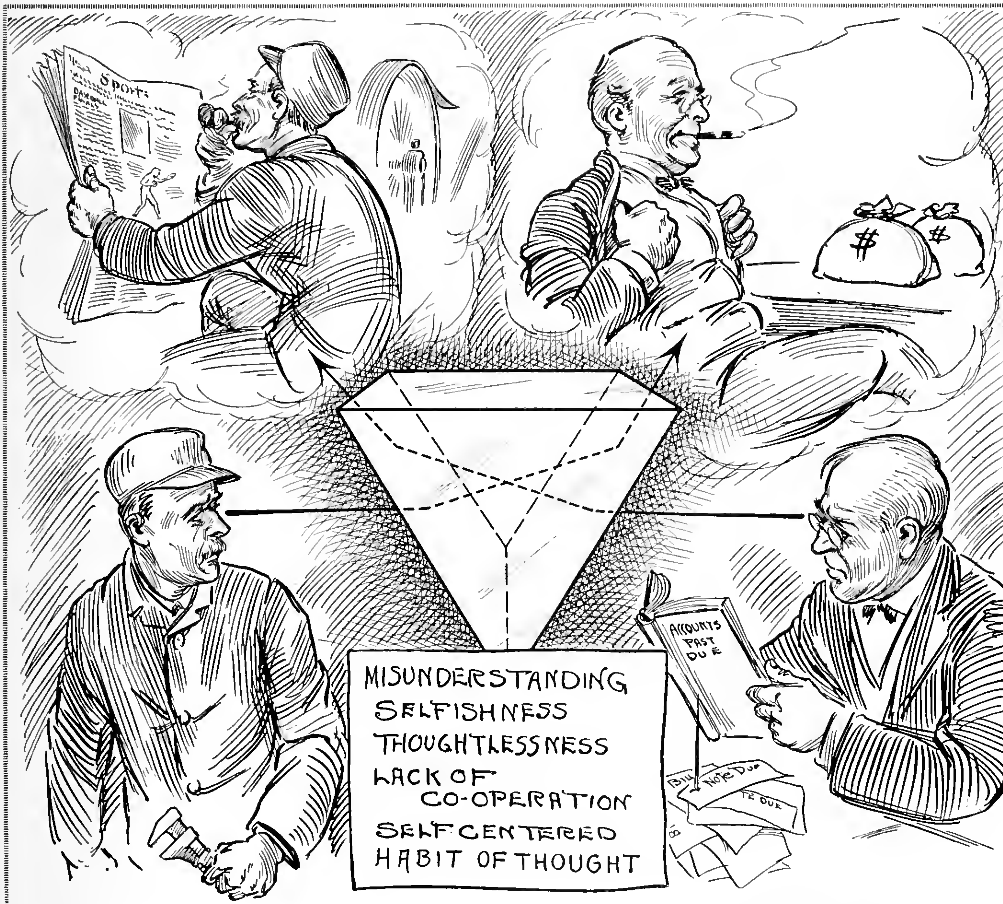
MASTER MECHANIC, 28, twelve years' experience with steam engines (all types), boilers and general machinery; knowledge of theory and practice in mechanical and electrical engineering; excellent references. P. W. 514, Power.

A CAPABLE ENGINEER at present employed as chief engineer in a modern plant desires change where opportunity for further advancement is greater; can furnish references as to character, ability, etc. P. W. 512, Power.

CHIEF ENGINEER, technical education, broad experience, energetic, successful in handling plants and men, open for engagement July 1; desires responsible position; best of references as to ability and character; age 42. P. W. 522, Power.

POWER

Vol. 41 NEW YORK, JUNE 15, 1915 No. 24



(*Suggested by Wilbur R. Smith, Alton, Ill.*)

The Prism That Refracts Our Vision

Boiler Plant of the Bessemer Coal and Coke Company

By Warren O. Rogers

SYNOPSIS—Six 72-in. return-tubular boilers are installed in pairs, with but one combustion chamber and one stoker for each pair. The fuel used is unsalable bone containing from 30 to 40 per cent. of noncombustible and averaging from 8000 to 11,000 B.t.u. per pound as fired.

A practice that will attract the attention of engineers is the burning of high-grade coal in the furnaces of coal-mining boiler plants. An instance where this is not done is at the power plant of the Bessemer Coal & Coke Co., Russellton, Penn., where a grade of fuel for which there is no market is burned with the aid of mechanical stokers, each feeding a common furnace for two return-tubular boilers.

The mines are about eighteen miles northeast of Pittsburgh, on the Bessemer & Lake Erie R.R. The main boiler plant consists of eight return-tubular boilers, 72 in. in diameter and 18 ft. long, each rated at 150 hp. Six are in one boiler house and two in another. The six were originally hand fired, the furnaces being supplied with steam jets to assist in the combustion. The other two were equipped with mechanical stokers supplemented by steam jets, with the idea of burning the bone which came from the mine. The arrangement did not prove satisfactory in operation, because of the high percentage of noncombustible in the fuel, so the furnaces were all burning the best slack and $\frac{3}{4}$-in. nut coal, worth $1 a ton at the mine.

Superintendent of Mines J. G. Bart believed that low-grade fuel could be burned if a properly designed stoker were installed. An unusual condition exists in this mine.

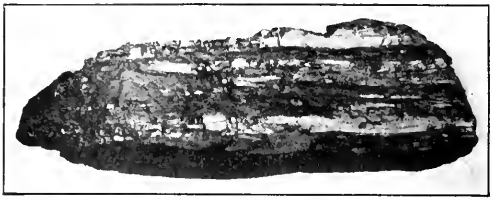


Fig. 2. Piece of Bone, the Bright Streaks Being Coal

There are two seams of coal about 3½ ft. thick and between them is a binder of bone composed of layers of slate and thin strata of coal. This is shown in Fig. 1. A piece of bone that was taken from a car of fuel is shown in Fig. 2 about one-half size. The bright streaks are the layers of coal, the dark portion being bone. Before the machine was put to work removing the bone, the latter was placed to one side by the miners and at convenient periods was hoisted to the surface and hauled away. The production was about 60 carloads a month,

Fig. 1. Cutting Machine Removing the Bone Binder from Between the Two Seams of Coal

and the cost of its removal, with an average haulage charge of about $6 a car, was not far from $360 a month, or $4320 a year. This bone has a heat value of between 8000 to 11,000 B.t.u. as delivered to the furnaces and an ash content of between 30 and 40 per cent.

To save the 100 tons of marketable coal that was burned each 24 hours under the eight boilers, to cut the cost of hauling away the bone and at the same time to reduce the boiler-room labor charges kept Superintendent Bart on the trail of a stoker that would fill the requirements.

About two years ago the work of installing a Taylor three-retort, underfeed stoker under each pair of boilers, or three stokers for the six boilers in the larger room, was

Fig. 3. A Three-Retort Underfeed Stoker Serving Two 72-In. Return-Tubular Boilers

begun. A single boiler would require a two-retort stoker and by placing two boilers over one three-retort stoker the initial cost was lessened and the efficiency was not reduced. Since the installing of the stokers, the boilers have been operated at 175 to 200 per cent. rating.

Fig. 3 is a view of the boiler room, showing the stokers placed with their center lines midway between the two boiler units. Fig. 4 shows the stokers from the rear end of the boiler setting.

The boilers are hung in pairs from steel railroad rails weighing 100 lb. per yard. The shells are separated 6 in., and the space between is filled with plastic cement. Fig. 5 gives a general idea of the method of placing the boilers. Each setting is 18 ft. 6 in. wide, with the boilers 6 ft. 6 in. center to center. The stokers are each 6 ft. $2\frac{1}{2}$ in. wide and extend under the boilers 9 ft. $9\frac{1}{2}$ in. They are operated by the fan blower, Fig. 6. From the top tuyeres to the boiler shells the distance is 3 ft. 6 in., and the top of the bridge-wall is 4 ft. from the bottom of the shells. The combustion chamber back of the bridge-wall is 11 ft. 9 in. wide and 12 ft. 9 in. long, with a height of 5 ft. 6 in.

Forced draft is obtained from an 8x10-in. engine-driven 9-ft. fan blower running at 320 r.p.m., which delivers air to a main duct 5 sq.ft. in area, running along the rear end of the boilers, and from which two branches, each 18 in. square, are taken to each stoker. These branches join to a wind box below the stoker. An air pressure of from $\frac{1}{2}$ to $\frac{5}{8}$ in. of water is maintained

Fig. 4. Furnace and Stoker Serving Two Return-Tubular Boilers

in the box under the stokers. Fig. 6 shows the general arrangement of the boiler, fan and air ducts and ash-disposal trench.

The bone fuel now used with the stokers is removed from the mine after being cut out from between the two seams of coal, and is hoisted to the surface, dumped into a single-roll crusher and then discharged to a double-roll crusher, which delivers it to a belt conveyor in

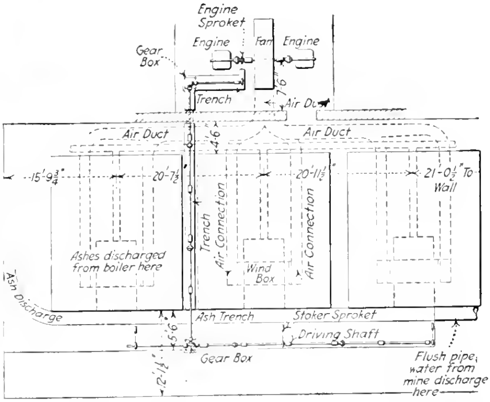


Fig. 5. Plan of Boilers, Ash Trench and Air Ducts

sizes not larger than $1\frac{1}{2}$-in. It is then carried to an overhead bunker having a capacity of 250 tons, or about two days' supply.

It is interesting to note that under former operating conditions eight boilers were required to carry the load, and about 100 tons of marketable coal was burned each 24 hours; the boiler-room force consisted of 10 men, five to each 12-hour shift, and it was difficult to keep

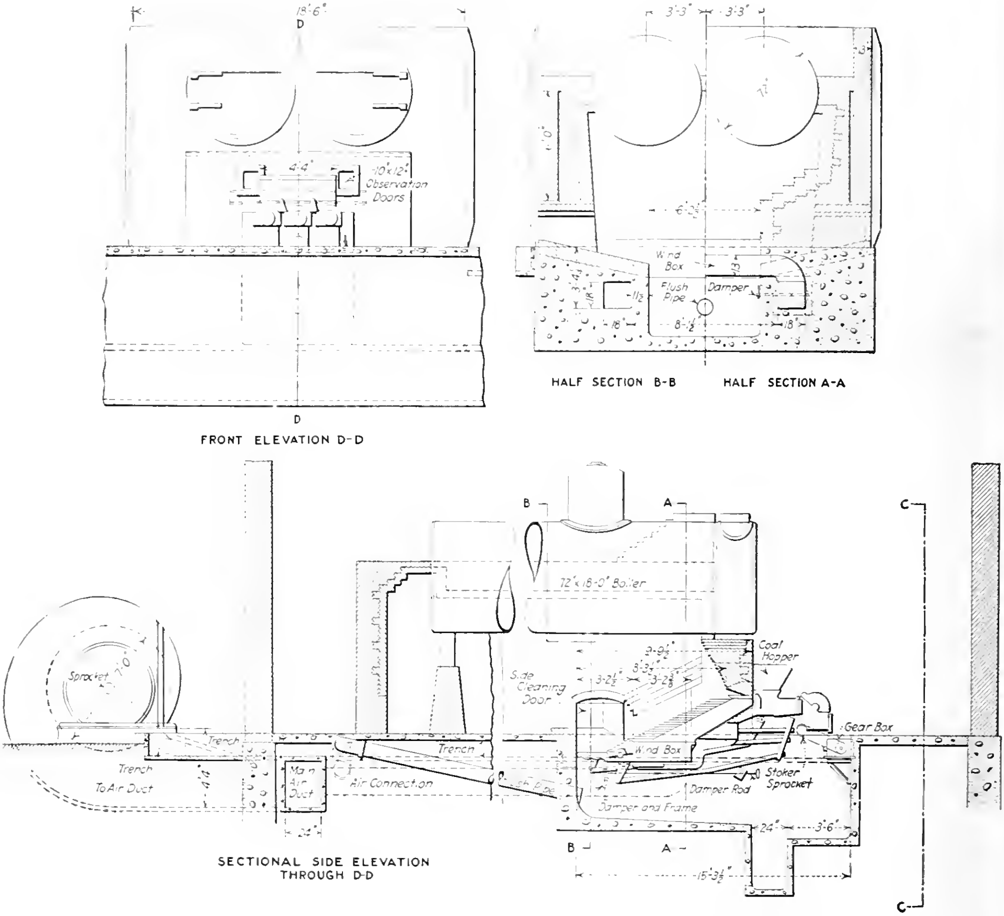


FIG. 6. DETAILS OF THE BOILER SETTING, AIR DUCTS AND ASH TRENCH

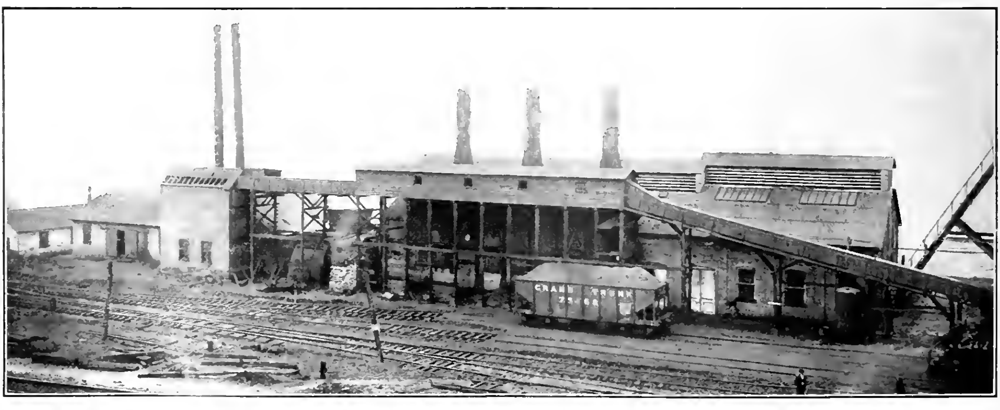


FIG. 7. GENERAL VIEW OF THE POWER PLANT OF THE BESSEMER COAL & COKE CO.

them owing to the hard firing conditions. The six boilers with their stokers now carry a heavier load than before the change, owing to the increased output of the mine and the substituting of an electric haulage system in place of mules. The boilers total 900-hp. normal rating, but have frequently delivered from 1600 to 1800 hp. with but three men on a shift, or six men for the 24 hours.

One hundred dollars' worth of marketable fuel is saved a day, and refuse that formerly cost about $6 a car to

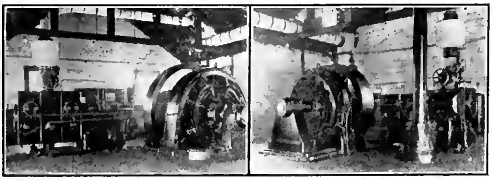


Fig. 8. The Two Generating Units

remove for filling-in purposes is for the most part burned in the boiler furnaces, and the removal cost of between $300 and $400 per month is saved.

An interesting method of disposing of the ashes has been worked out. They are flushed from the ashpit by a 10-in. stream of drainage water pumped from the mine. In front of the boiler a trench has been constructed, as shown in Figs. 5 and 6, 24 in. wide at the bottom, but with a shelf 3 ft. 6 in. wide at the top, making a total width of 5 ft. 6 in. The extreme depth of the trench is 3 ft. 6 in. The purpose of the shelf is to give an additional water head for flushing out the ashes.

The ashes are shoveled into the trench, which is below the level of the ashpit. A gate is provided at each boiler and when ashes are to be removed the last gate is closed until a head of water is obtained, when it is opened and the velocity of the escaping water carries the ashes with it. The plant is located at a considerable elevation and the trench discharges at the edge of the hill where there is sufficient ground to take care of the ashes for years to come.

The boilers are fed under normal conditions through a top connection, but in case of an emergency they may be fed through the blowoff. Each boiler connection to the header is provided with a nonreturn valve and the 12-in. header is likewise protected. A steam pressure of 100 lb. is maintained by the automatic speed control on the blower engine.

A general view of the plant from the railroad side is shown in Fig. 7. The three 45-ft. stacks serve the six boilers, and the two taller stacks the other two. At the extreme left is the engine room, which contains two units: One a 500-hp., four-valve engine directly connected to a 300-kw., 550-volt, direct-current generator at 150 r.p.m.; the other a 300-hp. engine directly connected to a 200-kw., 550-volt, direct-current generator at 180 r.p.m. The hoisting engine is in another engine room; it has a 26x36-in. cylinder and operates a hoist 260 ft. deep at a rate of 170 cars per hour, with an average of two tons per car.

A 10x10-in. engine directly connected to a 40-kw., 220-volt, direct-current generator is used for town lighting, and as it is in the hoist-engine room, requires no special attention.

The plant has attracted considerable attention because of several novel features, but chiefly because of the burning of a fuel that it had previously been impossible to use in a boiler furnace.

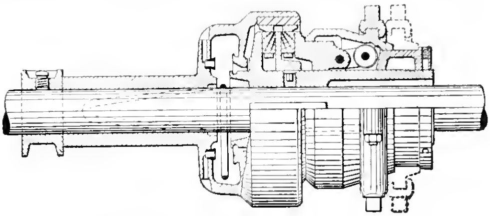
Dodge Safety Self-Oiling Clutch

An improved solid multiple-disk friction clutch that retains all the good points of the present clutch, with the addition of the important features of safety, efficiency and durability, has been developed by the Dodge Manufacturing Co., Mishawaka, Ind.

All moving parts of the mechanism of this new clutch, illustrated herewith, are concealed, making a smooth contour, so that there are no projecting moving parts. The design of the multiple friction disks, combined with the new roller toggle-operating mechanism, makes it a powerful clutch for its size.

The rolls on the toggle levers travel on conical surfaces arranged to give high pressure on the friction disks with a minimum amount of mechanism friction. The use of rollers in place of sliding parts makes the device easy to operate. The action of centrifugal force tends to keep the clutch disengaged when thrown out.

The apparatus is self-lubricating. An oil ring, revolving in a large chamber, or oil reservoir, carries a continuous supply of lubricant, which is circulated



Semisectional View of the Dodge Safety Self-Oiling Clutch

through suitable grooves to all parts of the sleeve carrying the pulley. This chamber is sealed to prevent oil working out into the mechanism. The shifter ring for engaging the clutch is made with a channel section that retains oil and assures lubrication at this point.

The clutch can be easily adjusted with a single nut adjustment that is simple and positive. Backing off this nut permits of the removal of the operating cone; this exposes the toggle mechanism and allows the removal of the inside mechanism for repairs. The best materials are used throughout.

The device may be easily applied to stationary or portable tools or countershafts, as well as pulleys, gears, sprockets, etc., and is especially suitable for high speeds.

Pasadena Electric Rates—Electric consumers in Pasadena, Calif., had to pay 15c. maximum per kw.-hr. up to 1908, when the city erected its own plant. The private company began its fight against the city by a reduction to 12½c. The city began operations with an 8c. rate; the private company met it. In 1910 the city made its lighting price 5c. maximum with a wholesale rate of 3c. and a power schedule of from 4c. to less than 1c. It is estimated that the saving to the city has been $100,000 per year since the plant was established. In 1913 the private company tried to put the Pasadena plant out of business by making its maximum rate 4c. in Pasadena, while it charged surrounding towns with no public plants at 6½c. to 10c. The State Legislature prohibited the company from making the other towns bear the losses of the company in Pasadena.—New York "American."

Getting Capacity in the Refrigerating Plant

By A. G. Solomon

SYNOPSIS—Is the plant that you have spent so much time on this spring giving its rated capacity? Is the condenser handling the gas as it should? Is the gas going to the compressor at the proper density and pressure, or is it superheated far more than is unavoidable? Can you add more load? These questions are well considered in this article.

During the next six months there are several questions which the engineer will ask himself: Is the full tonnage being got out of the plant? Are the ammonia compressors handling the amount of gas they should? Is the gas going to the compressors at the proper density and temperature? Are the direct-expansion coils handled properly? Are the brine and ice tanks handled right? Are the ammonia condensers doing their share of the work? Is the ice machine big enough to do the work demanded? Can a little more load be added?

The main question is to get the full capacity when it is needed. One part of the system may be holding all the other parts back.

Usually, the compressor is the first part considered and blamed when the temperature of the coolers and freezers begins to increase. In most cases putting the blame on the compressor is not justified. There is not much that can go wrong with the compressor. Leaky valves and pistons may happen, but are not likely except from long service. If the valves are ground in once a year and the cylinders and pistons examined and put in good condition at the same time, they will remain tight during a season's run.

Scale and dirt from the pipework may cut cylinders and valves, but there is little excuse for this. There are scale traps (or should be) on the suction lines to the compressors, and if they are cleaned at regular intervals the scale will be caught. All new pipe intended for ammonia systems should first be hammered and scraped to remove the scale. With reasonable care the compressor should give little trouble.

Condition of the Ammonia

So this really puts the success or failure of the plant on the manner in which the ammonia is handled. First, we will have to be sure that it is really anhydrous ammonia that we have in the system. There are two things that may be circulating in the system and taking up room and not giving good results. They are noncondensible gases and moisture. The so-called air is the most common and manifests itself as follows: Increased condenser pressure and consequently increased back pressure; frost melting from the machine and from the suction line; whistling sounds at the expansion valves; high discharge temperature and warm liquid lines and receiver. Sometimes, an insufficient charge of ammonia is taken as a sign of air in the system. The symptoms are somewhat the same. There should be a glass gage on the liquid receiver, and this should show at least half full when the machine is running on its proper load. If the liquid gets low in the receiver, the gas is allowed to enter the liquid line and then passes on to the evaporating coils, the compressor and condenser.

It goes through the evaporating coils, and instead of taking up heat by being vaporized it simply becomes superheated. The heat taken up by this gas is as nothing in comparison to that absorbed by the liquid, but the power required to pump it is about the same. So, before purging the system of air, put in enough ammonia to fill the receiver at least half full. Then, if there are indications of air, purge the condensers. Do not expect to get all the air out at one purging, but keep at it once a day till it is gone.

Moisture is sometimes allowed to remain in the system from careless handling during the steaming out of the evaporating coils. This does not often happen and seldom is the cause of serious trouble. Moisture in the system will in time show up in the oil traps and in the discharge-gas receiver. It will look like dirty water and is often called dead ammonia. No matter how full of ammonia this water is, it has no place in the system if it lies in the bottom of the gas receiver or oil trap. If there is an ammonia regenerator or purifier in the plant, the good ammonia can be boiled out and the moisture drawn off. But if there is no purifier, throw the dead stuff into the sewer. Noncondensible gases and moisture should not be troublesome in the plant, for they are easily got rid of.

Handling the Expansion Valves

Every engineer who operates a refrigerating plant is sure that he knows just how to handle the expansion valves to get the best results. It is a simple matter to open an expansion valve when a coil in a warm room is to be frosted.

We will assume that the cooler temperature has increased to 55 deg. The direct-expansion coils are either in a pipe deck above or else in the cooler itself. These coils are all free of frost. The proper way to begin to refrigerate this room will be to put on one coil and let it take up the steam and moisture from the atmosphere. This coil will frost quickly and will clear the room of steam. When frosted all the way to the return it should be shut off and another one put on. Do not open the expansion valves on all the coils at the beginning. This method of handling is to be recommended for two reasons. First, it will keep the coils more free from heavy frost and will give at least one clean coil to finish with. The coils that are used at first will be clean again, as the frost on them will be light, although thick, and will melt quickly.

The other reason is not so often considered, as its effect is not so plainly seen. We know that the ammonia that is in the coils when the room is hot is in a superheated state. The temperature of this gas will be the same as the temperature of the room. This gas will have to go through the ammonia compressor on its way to the condenser. The capacity of the compressor is rated by the weight of ammonia which it handles. The gas is light and occupies more space than a saturated vapor of the same weight. If this superheated gas is all sent to the compressor at once it will (for a time varying from fifteen minutes to one hour) greatly reduce the capacities of the compressor and the condenser.

To get an idea of how much difference there is in the space taken up by saturated vapor and superheated gas we have only to look at the ammonia tables. At 15.67 in. pressure one pound of saturated vapor will occupy about 9 cu.ft., while a pound of gas at a temperature of 55 deg. under the same pressure will occupy about 11 cu.ft. This superheated gas coming from the coils in the warm rooms will meet the saturated vapor from the coils in the cold rooms and cause superheating of the ammonia passing through the suction line on its way to the compressor.

If a wet or humid gas machine is used, a greater amount of liquid injection will have to be admitted during this time to keep the cylinder cool. If the compressor depends on a water jacket for the removal of the heat of compression, the gas will become more superheated on its admission to the cylinder. The temperature of this gas often reaches 150 deg. at the end of the suction stroke. No matter which way it is looked at, there is a distinct loss in refrigerating capacity when the warm cooler is first put on. By frosting one coil at a time and, by so doing, sending the hot gas to the machine in small quantities, the loss will not be so great. Another good plan to follow is to shut the expansion valves on all the coils in the rooms having a temperature below 32 deg., while getting the coils in the hot room frosted. These coils will then pump down and give up whatever ammonia is in them. This will give a greater amount of liquid to be circulated through the hot coils, and when they are first put on they will be able to evaporate more than when they become frosted. We know that the expansion valves can be opened much wider on a hot coil than on a cold one, as the greater temperature and amount of heat will evaporate much more ammonia. But do not forget that as the temperature of the room is lowered, the amount of ammonia fed to the coils must be decreased. If the expansion valves are left as first set, the ammonia will soon go to the compressor in a liquid state. This liquid will, by re-expansion, cut down on the capacity of the compressor. The condition of the ammonia reaching the compressor should be regulated by means of observation of a thermometer in the suction line. The closer this temperature is to the temperature of the saturated vapor at the pressure shown on the back-pressure gage, the greater will be the weight of ammonia handled by the compressor at a given speed.

Pipe Insulation

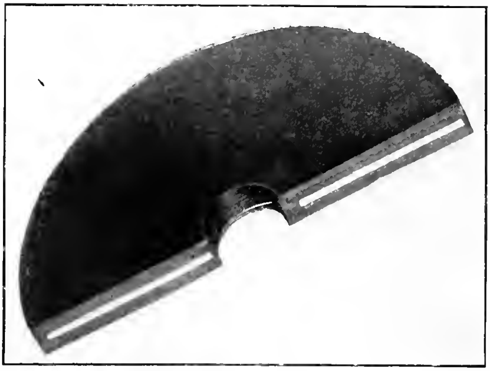
Superheating the ammonia by allowing heat to be absorbed through uncovered suction lines is a direct loss. A good rule to follow in a refrigerating plant is: Any pipe or apparatus which contains ammonia and is not used in the absorption of heat or the giving up of heat should be well insulated. This means to cover everything except the evaporating coils and the condensers. But the discharge line from the compressor to the condenser need not be covered, as the surrounding air will help to take away the heat caused by compression. The ammonia liquid line need not be covered in such places where the temperature of the rooms through which it passes is lower than the ammonia in the pipe. Do not allow an uncovered liquid line or a liquid receiver in a place where the temperature is higher than the condensing water used on the ammonia condenser.

The ammonia goes to the condenser to give up the heat it collected while evaporation was taking place. Here, we see the loss in condenser capacity caused by superheat. The gas must first be reduced in temperature to that of the saturated vapor at the condenser pressure before liquefaction takes place. So some of the condensing surface is used in taking away this superheat instead of liquefying and cooling the ammonia. After the ammonia is liquefied it should be cooled to the temperature of the coldest water available. Most plants use a cooling tower and reservoir and have a well or city-water line for making up what water is used or lost by wind and evaporation. This makeup water is, as a rule, much colder than the reservoir water and should be used for cooling the liquid before it is allowed to mix with the reservoir water.

The even distribution of water on the condenser is also necessary. Do not have some coils flooded while others are nearly dry. Have every foot of pipe doing its share of the work. Small leaks must be attended to just as soon as they are found, as they are generally the sources of loss of the ammonia. The big leaks are fixed at once, and the small ones should receive the same strict attention.

"Rub-Steel" Pump Valve

This pump-valve disk is a combination of rubber and steel. It consists of a steel plate placed in the center of the valve with a rubber composition on each side and edge; the rubber is attached to the metal by a chemical process. The plate embedded in the rubber is shown in the illustration. Its object is to give such strength to the valve that the pressures against which it works cannot



Reinforced Rubber Pump Valve

warp, twist or in any way get it out of shape. The rubber surfaces afford the proper seating qualities.

On account of the rigid reinforcement, the valve is kept in its true shape, high pressure is prevented from forcing the valve through the web of the valve seat and dishing of the valve is avoided.

The "Rub-Steel" valve disk is manufactured by the Voorhees Rubber Manufacturing Co., 18-50 Bostwick Ave., Jersey City, N. J.

Operation and Design of Auto-Transformers

By Norman G. Meade

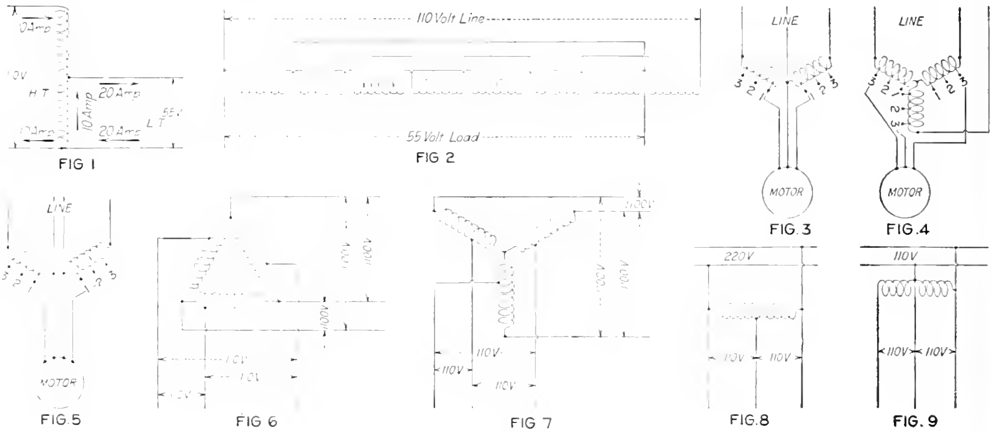
SYNOPSIS—The uses of auto-transformers and some of the corresponding connections; also the calculations and directions for constructing one of 10-kw. capacity.

The most common use for auto-transformers is the starting of induction motors, to supply a gradually increasing voltage as the motor accelerates. Other applications are balancing coils for three-wire distribution systems and three-wire direct-current generators, single-phase railway systems, and for general service where the ratio of transformation is not large.

There is only one winding per phase, serving as both primary and secondary, as is shown by the circuits of a single-phase auto-transformer in Fig. 1. Here the same two auto-transformers, one connected to each phase of a two-phase, four-wire circuit for starting a two-phase motor. Ordinarily, there are several taps in each auto-transformer connected to a controller to provide a gradually increasing voltage for starting.

Delta connections of a three-phase auto-transformer are shown in Fig. 6 and the Y-connections of a similar auto-transformer in Fig. 7. Both of these arrangements may be used for stepping up or stepping down the voltage.

Auto-transformers as applied to three-wire systems of distribution are shown diagrammatically in Figs. 8 and 9. In the former the auto-transformer is connected across a 220-volt line with the neutral tapped in at the center, giving 110 volts between each outside wire and the neutral and 220 volts between the outside wires. In Fig. 9 the



Connections for Auto-Transformers

number of turns is required as in the primary of a two-coil transformer of equivalent rating and where the ratio of transformation is approximately 2 to 1; also the same weight of copper as in the primary winding of such a transformer. The voltage per turn is uniform throughout the winding, and to secure a low-tension voltage of 55 when the high-tension voltage is 110, it is necessary only to make a tap midway between the ends of the coil, as shown.

To supply 1100 watts on the low-tension side requires a current of 20 amp., but as this is opposed in time phase relation to the high-tension current in this section, there will be only 10 amp. flowing in the coil. Owing to excessive magnetic leakage when the windings are continuous, as in Fig. 1, it is customary to make up the winding of several interspaced coils as shown in Fig. 2.

Figs. 3, 4 and 5 represent, respectively, two V-connected auto-transformers arranged for starting a three-phase induction motor, three single-phase auto-transformers, Y-connected, for starting a similar machine; and auto-transformer is also designed for 220 volts, but is connected to a 110-volt circuit from one end tap and the center tap, giving the same voltages as in Fig. 8.

Design of Auto-Transformers

Assume that it is desired to design an auto-transformer of 10-kw. capacity for a 25-cycle, 440-volt circuit with a 2 to 1 ratio of transformation, the low-tension voltage to be 220. Let it be of the core-type construction with two legs and let the winding be divided into eight coils, four per leg. Assume the efficiency to be 95 per cent.

$$Efficiency = \frac{watts\ output}{watts\ input}$$

Then for an output of 10,000 watts the input will be 10,000 ÷ 0.95 = 10,526 watts.

This limits the total full load loss to 526 watts, which should be about equally divided between the core losses and the copper loss, with perhaps a little greater copper loss. Therefore, let the copper loss be 300 watts and the core loss 226 watts. Assume a magnetic density of 30,000 lines per square inch of cross-sectional area of the core, which is a fair value for 25-cycle circuits. Then from curves showing hysteresis loss it will be found that for a density of 30,000 lines at 25 cycles, the loss is 0.1 watt per cubic inch of core for a good quality of soft iron in sheets.

The eddy-current loss will be small in a properly constructed core; hence it may be taken as 26 watts and the hysteresis loss 200 watts. Then the volume of the iron in the core will be 200 ÷ 0.1 = 2000 cu.in. The plates should be from 16 to 20 mils in thickness for 25-cycle circuits, and the oxide on the plates with a sheet of paper placed about every half-inch should be sufficient insulation. The volume of the iron core has now been determined, and it remains to proportion the core itself. Fig. 10 shows the type of core selected, and in proportioning it due regard must be given to the winding.

The core will be made square in cross-section, with the corners chamfered slightly. If the cross-section is made very small, the cores will be long and thin, the magnetic flux N will be small, and the coils will have to be provided with a large number of turns to generate the required electromotive force. Long cores also give rise to a long magnetic circuit, thus increasing the magnetizing current. On the other hand, if the cores are made very short the wire will have to be piled up deep in order to get it into the winding space, and the yoke across the ends will have to be made longer. Deep windings also mean a greater length of wire for a given number of turns. The best proportions are largely a matter of experience. For preliminary dimensions let the proportions shown in Fig. 10 be used, all of the dimensions being expressed in terms of the thickness of the core. Make the height $7\,a$; the volume of the core will then be

$$V = (2 \times 3.5\,a + 2 \times 5\,a)a^2$$

a^2 being the area of cross-section and $5\,a$ the distance between the yokes. This gives

$$V = 17\,a^3 = 2000 \text{ cu.in.}$$

whence

$$a = \sqrt[3]{\frac{2000}{17}} = 4.89 \text{ sq.in.}$$

This would represent the thickness of the core if it were solid iron. Part of the cross-section, however, is taken up by insulation between the plates, and the corners are cut off slightly, so it will be well to make the core 5 in. square. The other dimensions shown in Fig. 11 follow from this.

The impressed electromotive force is equal and opposite to the resultant of the counter electromotive force generated by the winding and that necessary to overcome the resistance of the winding. The drop in the winding is small compared with the impressed electromotive force and for present purposes may be neglected, hence the counter electromotive force generated in the winding may be taken as equal numerically to the impressed electromotive force. The number of turns required to produce this will depend upon the magnetic flux N which threads through the windings. The maximum magnetic flux through the winding will be $N = B_{max} \times a$, where B_{max} is the maximum value which the magnetic density reaches during a cycle, and a is the cross-sectional area of the core. In this case B_{max} is 30,000 lines per square inch, and a is 25 sq.in. Therefore,

$$N = 30{,}000 \times 25 = 750{,}000.$$

Taking the electromotive force generated in the winding as the equal and opposite to the line voltage,

$$E = \frac{4.44 \times N \times T \times f}{10^8}$$

where

N = Maximum value of the magnetic flux through the core;
T = Number of turns on primary coil;
f = Frequency in cycles per second;
E = Impressed electromotive force.

Applying this to the present example,

$$440 = \frac{4.44 \times 750{,}000 \times T \times 25}{10^8}$$

$$T = \frac{440 \times 10^8}{4.44 \times 750{,}000 \times 25} = 528$$

To make ample allowance let the number of turns be 600, or 300 to each leg. The current equals 10,000 ÷

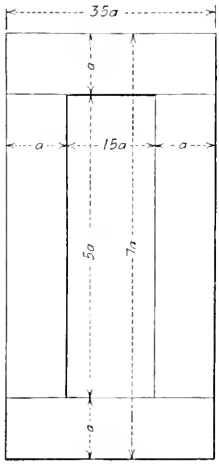


Fig. 10.

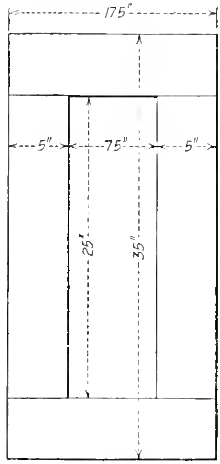


Fig. 11.

Core Dimensions

440 = 22.3 amp. Allowing 2000 circ.mils per ampere, the size of the wire will be 44,600 circ.mils, which corresponds nearest to No. 4 B. & S. gage. For this size of wire there are 4.5 turns to the inch. Allowing for insulation and space between coils, there will be approximately two layers on each leg. The approximate mean diameter of the coil is 7.5 in. and the mean length of one turn 23.5 in., say 25 in. The total length of the winding will then be 600 × 25 ÷ 12 = 1250 ft.

The resistance of No. 4 wire is approximately 0.25 ohm per thousand feet, which gives a resistance for the winding of approximately 0.32 ohm. The I^2R loss equals $22.3^2 \times 0.32 = 159$ watts. As the allowance for copper loss was 300 watts, this is well within the safe limits, and the efficiency will be greater than that assumed tentatively in the beginning.

Construction of Auto-Transformers

Having decided upon the core type of construction and determined the size of the core, the next step is to assemble the sheets. A wooden form should be provided, conforming to the internal dimensions of the core, and this should be laid on a level surface. Half of the iron sheets for the sides will be cut as long as the height of this form and half will be cut the overall height of the core. Similarly the ends will be made with half of the sheets as long as the width of the form and the other half as long as the overall width of the core.

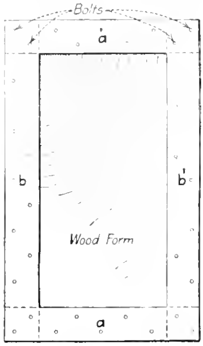


FIG 12

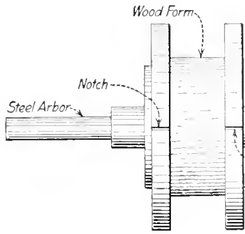


FIG. 13

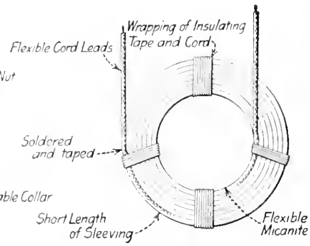


FIG. 14

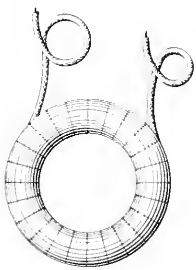


FIG 15

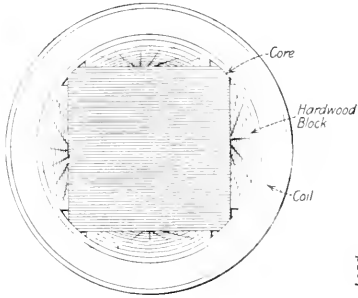


FIG. 16

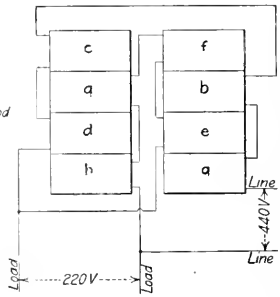


FIG. 17

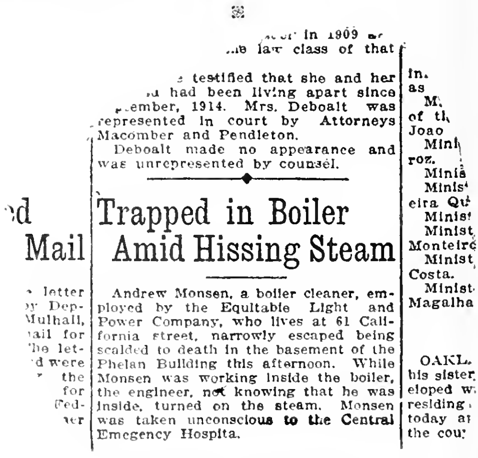
WINDING DETAILS AND COIL CONNECTIONS

Place two long strips, b and b' (Fig. 12), against the form and select two of the shorter end strips, a and a', and place them at the ends of the form. Next lay on two short strips b and b' and two long strips a and a'. This construction will give lapped joints. When the desired thickness of iron has been built up in this manner, the iron should be clamped, drilled and riveted, as indicated. The bolts can be removed and the top yoke withdrawn, leaving dovetailed connections for the top of the core. The core is then ready for the assembling of the coils.

The next step is to provide a form for the coils similar to that shown in Fig. 13. The distance between the collars should conform with the height of the coil, with the center slightly tapered to facilitate the removal of the finished coil. There should be about four slots on the circumference of each collar on the spool, in which pieces of cord are laid before winding is started. These cords are for binding the coil before removing it from the form.

Figs. 14 and 15 show, respectively, a partially completed and a completed coil. Flexible leads are soldered to the coil ends and insulated as shown. When the coil is wound, place a strip of flexible micanite around the inner surface and wrap with tape and cord at four places as shown, after which the temporary tie cord can be removed and the coil securely wrapped with webbing. It should then be heated to about 200 deg. F. and immersed in some good insulating compound and baked.

Provide some rounded hardwood blocks that have been thoroughly soaked in insulating compound and place them around the cores as shown in Fig. 16. Slip the coils in position with mica washers between them and between the top and bottom coils and the core. The coils should then be connected as indicated in Fig. 20, a, b, c and d being connected together as are e, f, g and h, and the leads joined as shown.


in 1909
the law class of that

testified that she and her had been living apart since ember, 1914. Mrs. Deboalt was represented in court by Attorneys Macomber and Pendleton.
Deboalt made no appearance and was unrepresented by counsel.

Trapped in Boiler Amid Hissing Steam

Andrew Monsen, a boiler cleaner, employed by the Equitable Light and Power Company, who lives at 61 California street, narrowly escaped being scalded to death in the basement of the Phelan Building this afternoon. While Monsen was working inside the boiler, the engineer, not knowing that he was inside, turned on the steam. Monsen was taken unconscious to the Central Emegency Hospita.

SAFETY FIRST! A LOCKED VALVE WOULD HAVE PREVENTED THIS ACCIDENT

Improvements in V-Notch Meter

In the Mar. 31, 1914, issue, page 115, was illustrated the Hoppes V-notch meter in the original form. Since then several improvements have been made. There are many places in which the recorder had to be located where there was considerable vibration, and this not only made a wide mark on the chart, but in some instances the integrator was so interrupted as to make it unreliable. To overcome these difficulties a much longer and heavier guide has been designed which has overcome the previous defects.

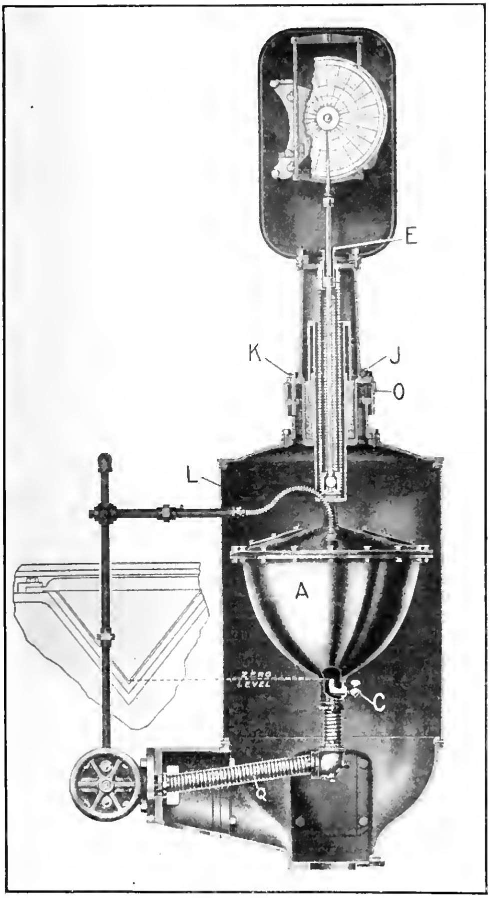


Fig. 1. Improved Weigher Recorder and Recorder Head

Figs. 1 and 2 show the changes made. In addition to improving the guide, the adjusting band O, Fig. 1, has been changed to the bottom of the column for adjusting the instrument to the zero level, which obviates the necessity for changing the brass sleeve E. All that is necessary now to adjust the zero level is to loosen the screws K and turn the band O up or down until the water drops slightly from the pet-cock C. All of the other adjustments have been made at the factory before shipment.

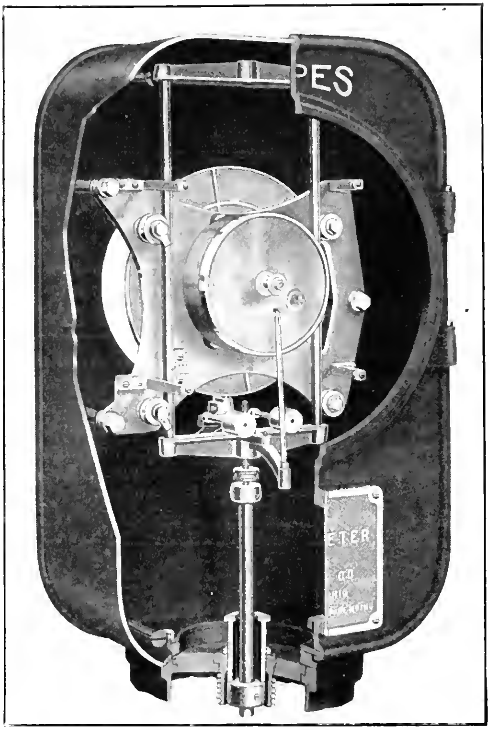


Fig. 2. Improved Recorder Head, Showing Chart Side of the Instrument

The improved recorder head, Fig. 2, is also made, when desired, to be placed below the cabinet L, as shown in Fig. 3. This is a desirable feature where the meter tank has to be placed at a considerable elevation above the floor or on the floor above the room where it is desired to have the recorder head. This illustration also shows clearly the connection of the water behind the weir with the weighing vessel, A, Fig. 1. These improvements add to the adaptability of the meter.

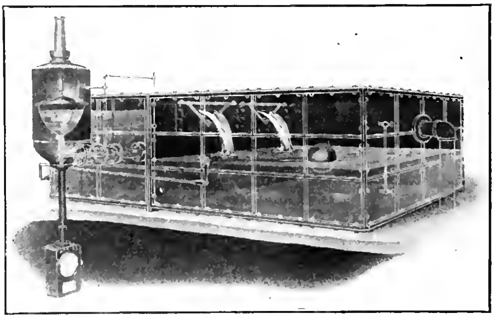


Fig. 3. Recorder Head Placed Below the Tank and Cabinet

Oxyacetylene Welding in Pipe Work

By W. Lee Roueche*

SYNOPSIS—Welded pipe is being more and more used each year, and the progress of its application is therefore of interest to watch. The relative cost of welded and flanged steam header favors the former. The article illustrates some interesting examples of pipe welding and gives valuable results from destruction tests on welded pipe.

It is only in the past decade that the design and construction of piping systems for power plants have received the careful thought and study of designing engineers which their importance warrants. Joints and massive fittings have been a potential source of trouble and expense, and a minimizing of their number is desired. The perfecting of the oxyacetylene torch has made this possible and also has enabled better engineering.

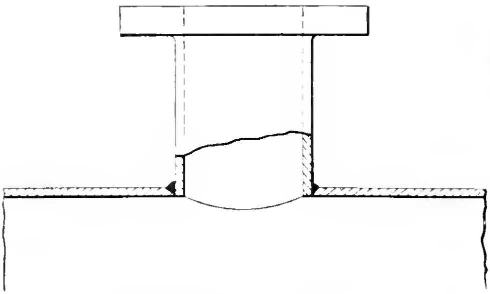


Fig. 1. Section Showing Construction of Welded Joint

The old-style header, built up with cumbersome flanged fittings, is fast becoming obsolete. It is now practical to build headers of the same relative strength as the pipe itself and in lengths limited only by shipping and erecting facilities. The relative cost is in favor of the welded header, more particularly in the larger sizes and where there are a number of outlets. A welded job is also much lighter, therefore easier to erect and support. It is built of the same material throughout and avoids the uncertainties due to defective castings and unequal expansion strains. The number of intermediate joints is reduced to a minimum, and in many instances they are cut out altogether. It has been found practical to close the ends of headers with convex heads, dished to the proper radius and welded on, thereby doing away with all joints except those at the nozzle connections.

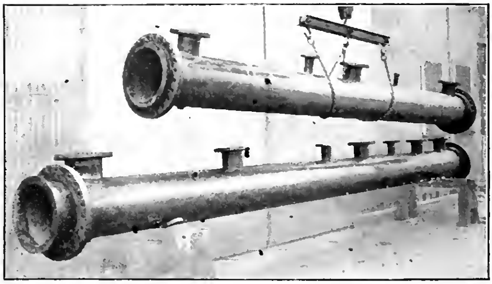


Fig. 2. Welded Header, 18 In. Diameter; Total Length 48 Ft. Note Outlets of Various Sizes

The usual method of construction is to take lap-welded merchant steel pipe of the proper diameter and thickness and where necessary weld together to get the desired length. The holes for the outlets are cut either in the usual manner or with the cutting torch. The nozzles are then welded on after being shaped to fit the curvature of the pipe. Different manufacturers have various methods of attaching the nozzles. The method used by the writer, which has proved to equal the strength of the pipe itself, is shown in Fig. 1. The pipe is beveled so as to form an angular groove of about 45 deg. with the nozzle. The fillet is then built up to the proper thickness. Nozzles of any size up to the diameter of the header itself have been successfully used. All welds are annealed after the header is completed, to relieve strains that may have been produced during the welding process. The

*With Crane Co., at Birmingham, Ala.

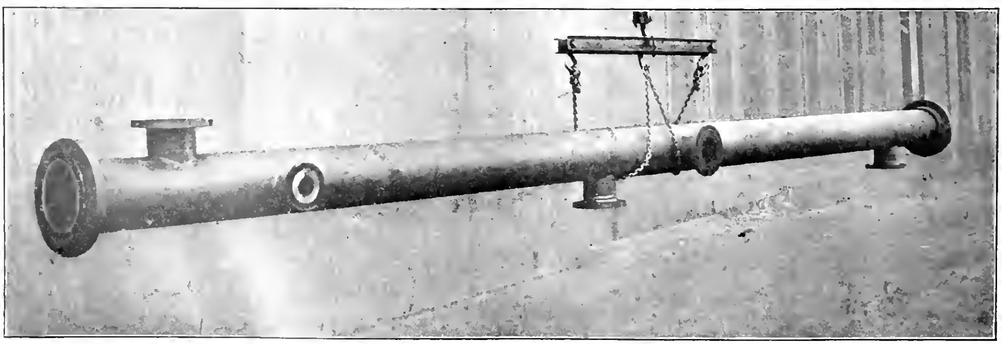


Fig. 3. Large Steam Header, 31 Ft. Long; Rolled Steel Flanges and Seamless Nozzles

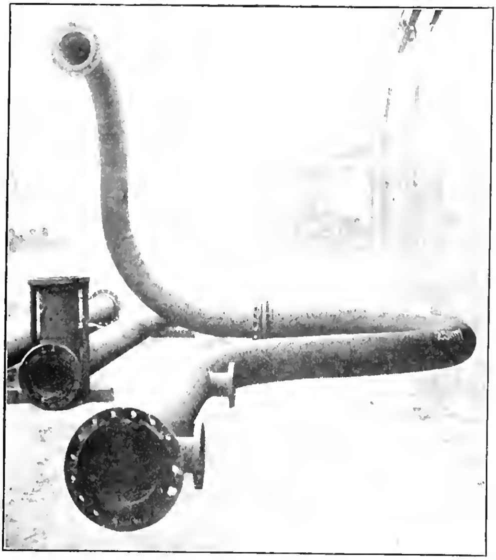


Fig. 1. Example of Welding Possibilities

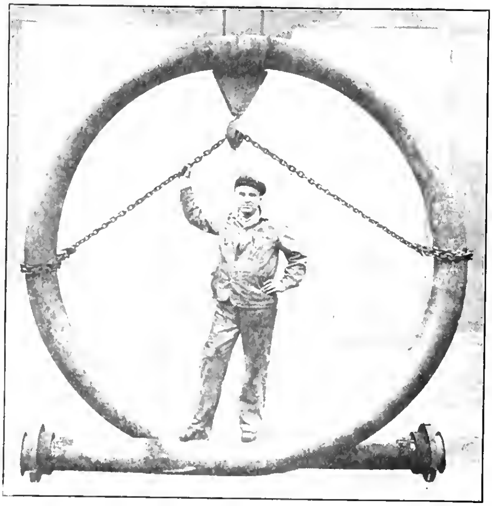


Fig. 5. An 8-In. Expansion Loop Having 37 Ft. of Pipe. Note Weld at the Top Just above Crane Hook

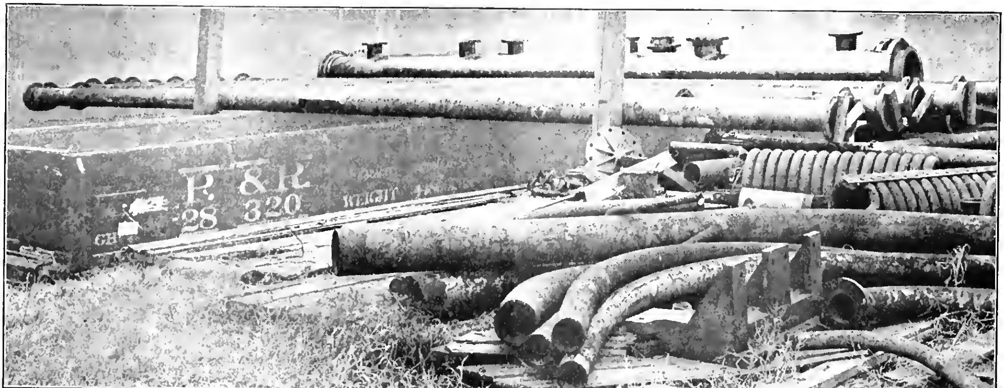


Fig. 6 (Above). Ten Lengths of 8-In. Pipe Each 40 Ft. Long
Fig. 7 (Below). An 8-In. Header, 30 Ft. Long. Note Nozzles at Each End

[illegible] hydraulic pressure 2½ times the working pressure.

Fig. 2 shows an 18-in. header 48 ft. over all, built in two sections, with six 7-in. boiler connections and five distributing outlets ranging from 2 in. to 10 in. This header was tested to 600 lb. hydraulic pressure and has been in successful operation for more than two years.

Fig. 8. Pipe Coil for Ammonia Plant; Has 180 Ft. of Pipe

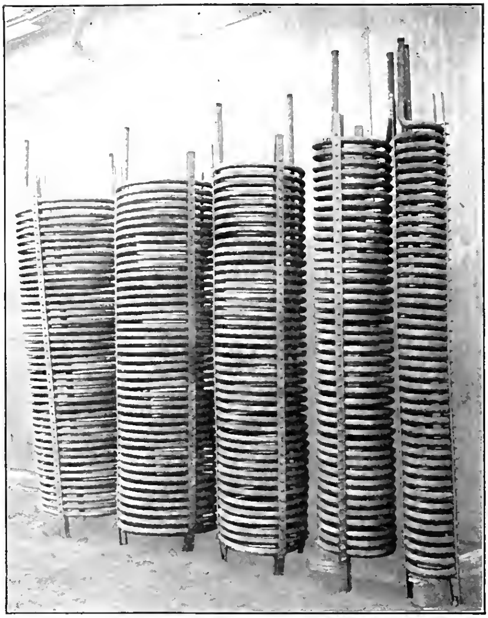


Fig. 9. Five Coils Having Total of 1400 Ft. of 1½-In. Pipe

Fig. 3 shows a 14-in. header 31 ft. 2 in. over all, with four 8-in. and one 4-in. seamless steel nozzles.

Fig. 4 is a good example of work that would have been practically impossible without the welding torch. All the headers are of 14-in. o.d. pipe ⅜ in. thick. The gooseneck was originally made in four sections and then made into two by welding. The location of the welds can be clearly seen in the photograph. The whole was installed in the same relative position as shown. The 14-in. outlet on the middle header connected to the upper end of the gooseneck. These headers were built to meet a peculiar condition in a Southern plant and have been in service about two years.

Fig. 5 is a further example of the advantages of the oxyacetylene weld. This is a special 8-in. expansion U-bend made to suit special conditions. The weld can be plainly seen at the top, just over the crane hook. The finished bend contains 37 ft. of pipe.

In long runs of pipe it is possible to eliminate from 40 to 50 per cent. of the joints. Fig. 6 shows ten lengths of 8-in. pipe for a high-pressure steam line averaging over 40 ft. each.

Another good example of a welded header is shown in Fig. 7. This is an 8-in. header 30 ft. over all, with two 8-in., two 6-in. and two 5-in. seamless steel nozzles. The 8-in. and 5-in. nozzles are in the same plane set at 90 deg. to each other.

The possibilities of oyxacetylene welding in all classes of pipe have only just begun to be realized. It is being successfully used in ammonia work, where there is a wide field for it. Figs. 8 and 9 are good specimens of this class of work. The former is for a reboiler in an absorption plant. The coil is 19 in. outside diameter and contains 180 ft. of 1½-in. extra heavy pipe. Fig. 9

shows a set of the same kind of coils which nest together, the five coils containing about 1100 ft. of 1½-in. extra heavy pipe. These coils were tested to 800 lb. hydraulic pressure.

Destruction Tests of Welds

The writer has made several destruction tests in order to compare the strength of the weld with that of the pipe. These have proved conclusively the efficiency of the weld when properly made. In the first test, a piece of 12-in. full-weight pipe, 5 ft. long and equipped with lap-joints and rolled-steel high hub flanges, was used. A 4-in. seamless steel nozzle was welded on midway between the flanges, and the ends closed with extra heavy cast-iron blind flanges bolted on. At 2000 lb. hydraulic pressure one of the blind flanges gave way, while the weld showed no signs of stress. The second test was made with a piece of 6-in. full-weight pipe 5 ft. long. The pipe was cut in the middle and butt-welded with the torch. The ends were fitted with lap-joints and rolled-steel flanges and blanked with extra heavy cast-iron blind flanges. Three blind flanges were broken in succession at hydraulic pressures of from 2100 to 2300 lb. The bolts showed stress at 2300 lb. One end of the pipe was then cut off and a ⅜-in. thick convex head butt-welded on. A special flange was made for the other end and the bolts increased from twelve ⅞-in. to twelve 1-in. Hydraulic pressure was again applied. At 3300 lb. the flanged joint failed owing to the dishing of the rolled-steel flange. Neither weld on examination showed any indication of failure. The theoretical bursting pressure of 6-in. full-weight pipe, as given by the manufacturer, is 1200 lb., and this test was made without annealing the welds. It was found that the outside diameter of the pipe was increased almost ¼ in. The third test was made with a piece of 5-in. full-weight lap-weld merchant pipe about 6 ft. long, butt-welded in the middle as in the second test, and both ends closed with a ⅜-in. thick convex head butt-welded on. At 2700 lb. the seam of the pipe opened up. This was welded with the torch and hydraulic pressure again applied. At 3950 lb. the pipe burst, rupturing the metal longitudinally to one side of the seam where it had been rewelded with the torch.

Automatic Electric Control of Pumps

By George J. Kirchgasser

SYNOPSIS—An interesting description of the applications of automatic electric control devices for pumps in various kinds of service.

Probably the commonest type of motor-driven machine to which the automatic starter has been applied is the pump. From the small house and sump pump to the largest types used on water systems, automatic or remote control has proved of distinct advantage.

Sump pumps are used to keep basements clear of water. The basement floors of buildings of today are frequently below the level of the sewers and considerable water drains in after rains or thaws. A pit is usually provided so that this water is collected in one place. A small pump called a sump or bilge pump, usually driven by a vertical motor, is used to prevent overflowing into the basement. To automatically start and stop this pump so that there will be insurance against flooding the basement and against useless waste of electric power, is one of the common applications of the motor starter, or controller.

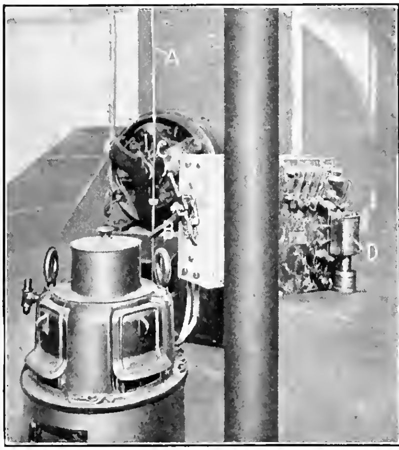


Fig. 1

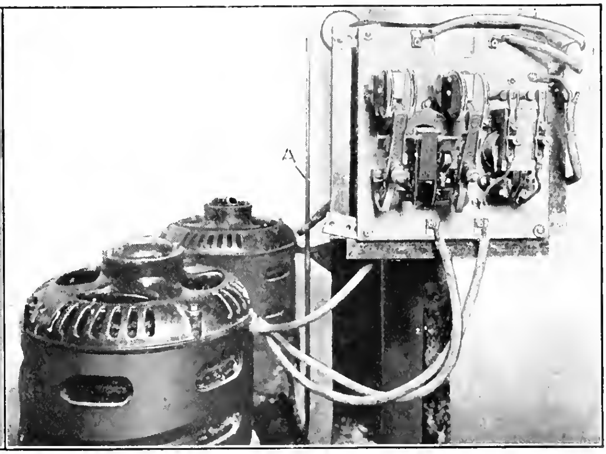


Fig. 2

Control Devices for Direct- and Alternating-Current Motor-Driven Sump Pumps

The illustrations, Figs. 1 and 2, show automatic controllers for direct-current and alternating-current motors.

In the first the float switch is mounted so that its operation is easily explained. As the water in the pit rises, the rod A, mounted on a float, rises also. This rod has two stops, one of which is shown. As the float and rod rise, the lower stop engages the movable arm B of the float switch. When this moves through a certain distance the weighted tumbler arm C of the switch causes the latter to close, and this in turn causes the solenoid D of the starter to become energized. The motor is thus started and accelerated to normal running speed. The pump will be driven until the water level has been lowered to a predetermined point. When this is reached the upper stop on the rod will have tripped the float switch open, which causes the automatic starter to cut the motor from the line and thus bring it to a stop. The pump may be put in operation for long or short periods, it may be started and stopped many times a day or only a few times a year, but no attention is required, and current will be used only when necessary and for as short a period as required to lower the water to the desired level.

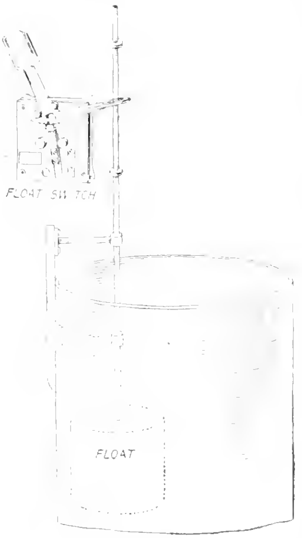


FIG. 3. THE FLOAT SWITCH

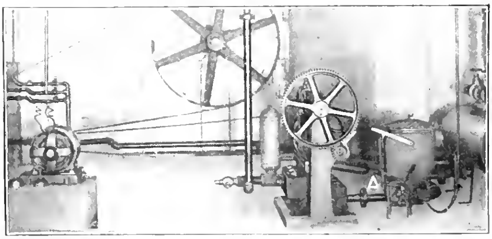


FIG. 4. THE FLOAT SWITCH OF THIS MOTOR-DRIVEN RETURN SWITCH IS ACTUATED BY THE WATER LEVEL IN THE PUMP GOVERNOR

For small sump-pump equipments operated by alternating-current motors the magnetic switch shown in Fig. 2 is used to throw the motor across the line or to cut it off, as the water level demands. In this installation the float switch, operated by the vertical rod A, is mounted on the post in back of the automatic starting-switch panel, one end of the lever alone being visible. Fig. 3 shows how the sump float is arranged.

Fig. 4 shows a simple but interesting application in a school building, of the same type of automatic switch and float switch. The latter is mounted near the floor (see A), while a magnetic switch is mounted on the wall and not shown in this view. A $7\frac{1}{2}$-hp., three-phase, 60-cycle, 220-volt motor of the squirrel-cage induction type is used. Back of the float switch is shown the automatic pump regulator and condensation receiver used in connection with the steam pump to automatically return the condensation from the heating system or other apparatus to the boiler. Fig. 5 shows such a receiving apparatus for returning condensation to the boiler, in which an automatic pump regulator and condensation receiver are employed. As the water rises, the float is raised and at a certain level causes the tumbler arm of the float switch to close the magnetic switch and set the motor and pump in motion. The float switch does not carry the motor current, but simply the energizing current which causes a magnetic switch (as in Fig. 6) to close and connect the motor to the line. After the level

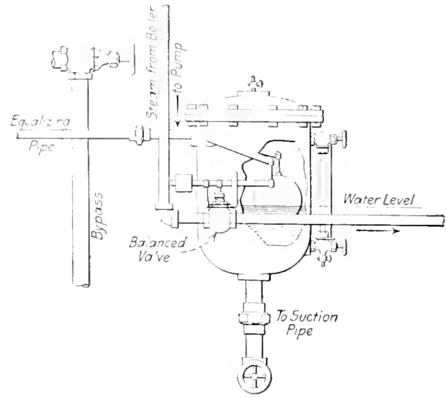


FIG. 5. SHOWING THE PUMP GOVERNOR

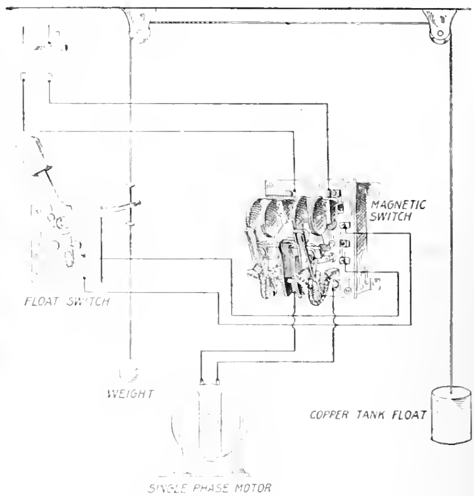


FIG. 6. AUTOMATIC STARTER FOR SINGLE-PHASE MOTOR

drops, the float switch is tripped open and the motor disconnected from the line.

In the keeping of any sort of open tank filled to a desired level the same methods of control may be used, except that the float and float-switch operations are opposite from those used in connection with the sump pump. In the ordinary tank system the motor is started and put in operation when the level is low and stopped when it reaches a desired high point. The same kind of float switch or an inclosed type may be employed. Figs. 6 and 7 show the wiring for automatic control of single- and three-phase motors respectively.

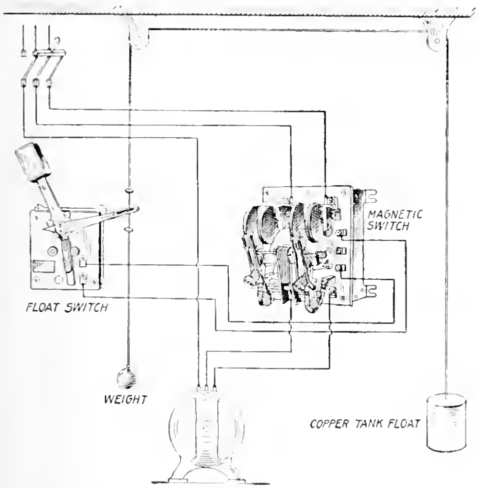


Fig. 7. Wiring of Automatic Starter for Three-Phase Motor

Pumps or compressors operating on closed systems are controlled in a similar way, the automatic starter being actuated by a pressure-regulated switch instead of a float switch, as shown in Fig. 8.

House pumps are required in all buildings where the city water pressure is not sufficient to supply the upper floors. These pumps are not required at all times, but only when the demand made on the system lowers the pressure maintained. To do this in the most economical and best way, automatic control of the starting and stopping of the pumps is necessary. The pressure requirements are thus always maintained. Fig. 9 shows two of three triplex house pumps in the Continental and Commercial National Bank Building, Chicago. These pumps are driven by 20-hp., 220-volt, direct-current motors automatically started and stopped by the three automatic

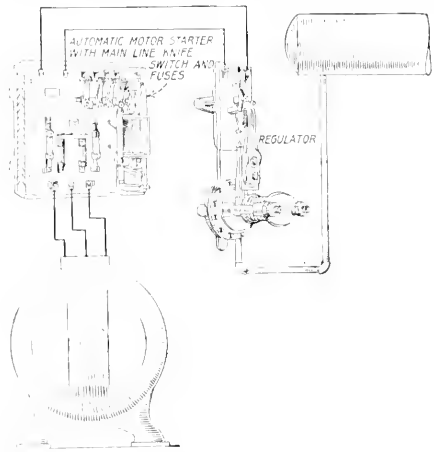


Fig. 8. Wiring and Controls for Starter for Direct-Current Motor

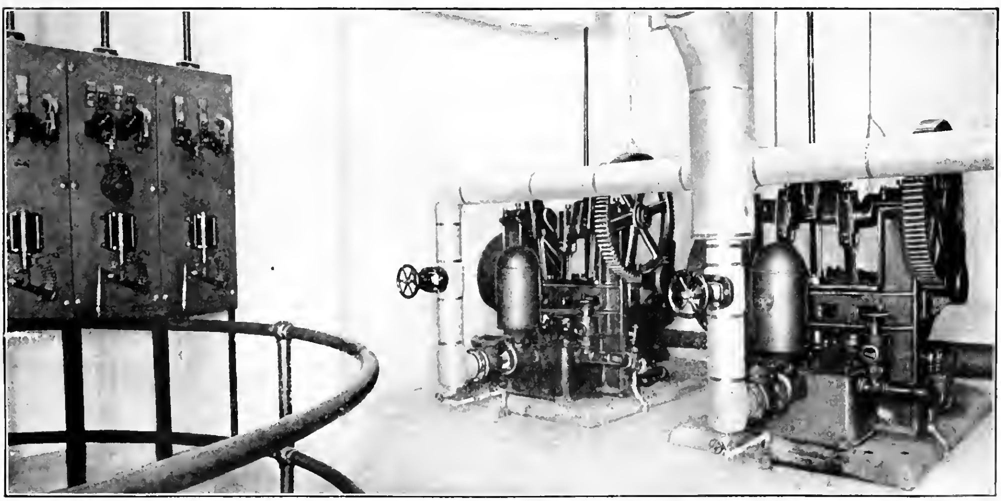


Fig. 9. Two of Three Electrically Controlled House Pumps in Office Building

First, one is cut in, then if the demand increases, another is started, and so on until the demand is met

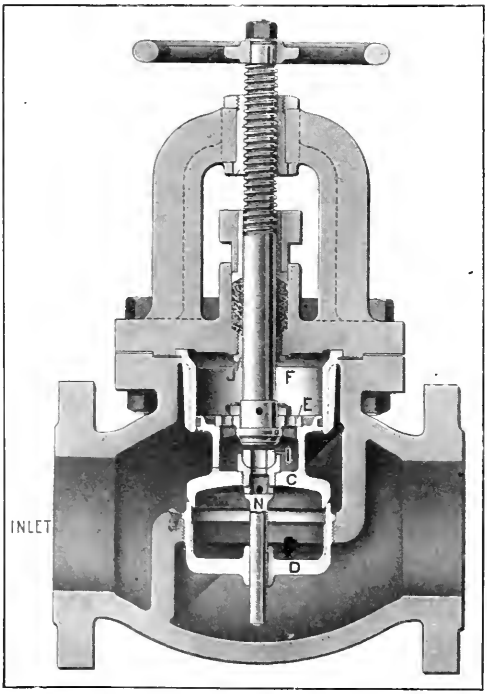
controllers shown on the panel. This equipment is arranged so that when the first demands are made, one motor is set in operation. If the demands of the service are greater than can be cared for by one pump, the second one is put in service and the third also, should it be needed. A pilot arrangement on the controller panels makes it possible to have any one of the three put in service first, followed by the others, thus dividing the work equally for a given period.

In the case of the automatic fire-pump controller any decrease in the pressure on the sprinkler system due to opening of a sprinkler head or to valve leakage causes the pump to be set in motion until the pressure supposed to be maintained in the system is again reached.

Similar machines, as vacuum cleaners, compressors and blowers, are also controlled automatically or by a push-button switch closing the automatic starter solenoid or magnetic circuit in the same way that a float switch or pressure regulator does. In buildings tenanted by dentists and physicians compressed air is usually furnished by compressors located in the basement and automatically controlled by pressure regulators and automatic motor starters, to keep a suitable pressure on the system regardless of the demand.

Lunkenheimer Balanced Throttle Valve

The balanced throttle valve illustrated herewith has been designed to operate with ease and with efficiency, combined with durability. When the valve is in place the steam enters above the disk, otherwise the value of



Lunkenheimer Balanced Throttle Valve

the bypass is lost. With the valve closed pressure enters the balancing cylinder past the piston ring and through the drain hole in the bottom of the disk cylinder. As a result, the pressure above the disk is equal to that in the inlet of the valve. This pressure aids in keeping the disk tightly sealed, and it is relieved by the bypass *I*, the opening through which is covered by the bottom of the stem when the valve is closed. When the handwheel is turned slightly, this opening is uncovered and the steam above the piston passes through the holes in the retaining ring *E*, thence through the hole in the bypass disk and through the drill holes in the bottom of the main-disk guide stem *N*; this relieves the pressure above the piston while the valve is being opened and the arrangement prevents pressure above the disk during the opening of the valve.

The drain hole in the bottom of the disk cylinder is to relieve the condensed steam that may accumulate in the cylinder when the valve is connected in a vertical position. When the valve is in a horizontal position the water in the disk and in the balancing cylinders will drain past the piston ring. Both the main and the bypass valves are operated simultaneously. Provision is made for regrinding the seating surfaces of the main seat and disk seating surface.

This valve is manufactured by the Lunkenheimer Co., Cincinnati, Ohio.

Long Chances with the Portable Engine

By Loe Addy

The operation of a portable engine is not a very angelic occupation, and at times it would seem that there must be a destiny to guard the operators from misfortune.

Upon one occasion, while overhauling a second-hand sawmill outfit, a wooden connecting-rod was used as a template for a new rod and was left on the engine when the workmen left the mill on Saturday evening. The next morning the owner, anxious to try his new engine, got up steam, turned it on and gave the flywheel a whirl. The wooden connecting-rod broke and the crosshead drove the stuffing-box gland through the cylinder head.

The engineer of a threshing outfit fed vinegar into the boiler at the rate of about six gallons a day for several days. It was supposed to prevent the foaming of the bad water taken from ponds and muddy copperas streams. The engineer said that the boiler needed blowing down, but he had twisted off the stem of the blowoff valve. The boiler had not been washed out in weeks. Its internal condition can better be imagined than described.

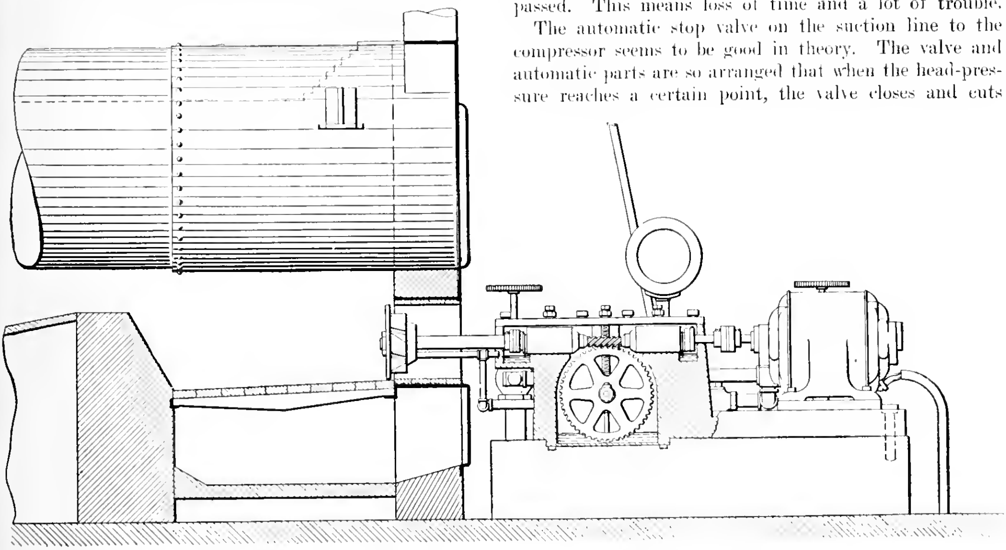
The speed of the sawmill engine was controlled by a lever bolted to one of the arms of the governor, from which the belt was removed. A wire attached to the end of this lever extended to a wooden lever within reach of the sawyer, thus furnishing means for shutting off the steam. When the wire was released the balls dropped by gravity, giving a full head of steam. The lever was secured by being hooked behind a nail in a post, to be released when the power was needed. It can readily be imagined about how sensitive the control was. They certainly placed great confidence in that wire and nail; for if the lever became unhooked or the wire broken, or even if the engine moved forward a trifle on its foundation, it would run wild under a full head of steam.

There certainly is no machine called upon to operate under as many trying conditions as the traction engine of a threshing outfit. A stationary engineer would hardly care to operate a unit under such conditions.

While descending a hill the furnace door is usually opened and perhaps the fire damped in order to protect the crown-sheet, which now has no water over it. At times on a short hill this precaution is not taken, and when level ground is reached the water comes surging back over the heated plate; yet, it is comparatively seldom that an explosion occurs. There are occupations more monotonous than that of the engineer of a traction engine.

Rotary Crude-Oil Burner

The rotary crude-oil burner illustrated herewith is manufactured by G. E. Witt Co., 862-864 Howard St., San Francisco, Calif. The principal feature is the placing of the burner on a horizontal shaft in front of the furnace, away from the heat, the air passing through it carrying the heat toward the back of the boiler, which overcomes trouble from overheating. The burner is driven by a motor, and the device is self-contained. With the exception of the burner, all of the apparatus is outside the furnace.



ROTARY CRUDE-OIL BURNER APPLIED TO A RETURN-TUBULAR BOILER

This burner is suitable for boilers of small capacity, and is noiseless in operation. It has also been applied to boilers up to 140-hp. capacity, which demonstrates its wide range of application for both high- and low-pressure work.

Peripheral Speeds—As compared with the 38 ft. per sec., which is considered the limit in safe speed for a cast-iron flywheel, some of the peripheral speeds attained by the disks of steam turbines are striking. In a paper presented to the Manchester Association of Engineers, R. F. Halliwell says: "The highest peripheral speed which it is possible to employ is probably found in the 300-hp. DeLaval turbine, in which, with a 30-in. wheel running at 10,000 r.p.m., a velocity of over 1300 ft. per sec. is reached."

Ammonia Compressor Alarm

By G. A. Robertson

There has been considerable comment recently among refrigerating engineers as to the proper manner of installing relief valves or other similar devices to guard against serious accidents from excessive head-pressure in the refrigerating system.

Some have located a relief valve in a bypass line between the suction and discharge lines of the compressor, and there have been a few installations of automatic suction stop valves. Both of these methods have features that are undesirable. The relief valve installed in the bypass between suction and discharge lines, is set so as to let ammonia gas in the high-pressure side pass to the low-pressure side of the system, when the head pressure for some reason has increased to an undesirable point. When this valve has been lifted off its seat once or a few times, it is almost sure to leak. In order to inspect it, guard valves would have to be installed, which are undesirable, or the engineer would have to shut down and pump out the pipe lines that were bypassed. This means loss of time and a lot of trouble.

The automatic stop valve on the suction line to the compressor seems to be good in theory. The valve and automatic parts are so arranged that when the head-pressure reaches a certain point, the valve closes and cuts off the supply of ammonia gas to the compressor. There is some doubt as to whether the valve would respond when needed, since it is likely to stand for a long time without operating.

The writer desires to call attention to an alarm installation for the compressor. An ordinary ammonia relief valve (about 1-in.) is placed between the cylinder and the guard valve of the compressor, and the outlet connected to a ½-in. whistle fifteen or twenty feet from the machine. The valve is set to blow at 25 or 30 lb. above the usual head-pressure. Just as soon as the pressure reaches this point the whistle blows and gives warning. Should the machine be started with the guard valve closed, the whistle gives warning immediately. The operator could then stop the compressor in time to prevent an accident.

Some Notes on Fans*

By A. A. Potter and S. L. Simmering

SYNOPSIS—Rules and approximate equations for the capacity and cost of fans and blowers.

For the production of artificial draft use is made of chimneys, fans, blowers and steam jets. Under ordinary conditions a chimney 125 ft. high will give a draft of about 0.75 in. of water, or about 0.43 oz. pressure, and a chimney 250 ft. high will give a draft of about 1.5 in. of water, or 0.87 oz. pressure.

A chimney, once built, is limited in its capacity, whereas a fan may ordinarily have a range of pressure from 0.25 oz. to 4 oz., depending on the speed at which it is operated. This range of draft pressure makes it readily possible to meet any overload which may be suddenly demanded of the plant. A combination of the natural or chimney draft and forced draft is frequently used. The chimney draft in this case is made sufficient to overcome the resistance to the flow of the gases due to the flues, passages and chimney walls, while the draft produced by the fan is sufficient to overcome the resistance to the air in passing through the fuel bed and also to supply the necessary air for the combustion of the fuel.

Air Required for Combustion

If the coal burned consisted of pure carbon and perfect mixing were possible, about 12 lb. of air would be needed for every pound of fuel burned. As a general rule, however, under actual operating conditions about 18 lb. of air is required per pound of coal. The volume of one pound of air at 32 deg. F. and atmospheric pressure is approximately 12.5 cu.ft.; hence, the total volume necessary at this temperature to burn one pound of coal is about 225 cu.ft. For any other temperature t the volume becomes,

$$\frac{(460 + t)\,225}{492}$$

If

w = Weight of coal burned per hour;
t = Temperature at which the air or gases enter the draft-producing apparatus;
A = Volume of air in cubic feet per minute;

then

$$A = \frac{225\,w\,(460 + t)}{60 \times 492} \text{ or, } A = wk$$

The values for k for different temperatures are as follows:

t	k	t	k
60 deg. F.	3.96	300 deg. F.	5.79
80 deg. F.	4.11	400 deg. F.	6.55
100 deg. F.	4.27	500 deg. F.	7.32
200 deg. F.	5.03	600 deg. F.	8.09

The forced-draft apparatus would handle the air at a temperature of about 80 deg. F., and an induced-draft apparatus at about 550 deg. F., if no economizer were used. Hence, from the above the following approximate rules are deduced:

Rule 1—The cubic feet of air to be supplied per minute by a forced-draft apparatus is equal to four times the number of pounds of coal burned per hour.

Rule 2—The cubic feet of gases handled per minute by the induced-draft apparatus when no economizer is used, is equal to eight times the number of pounds of coal burned per hour.

Capacity and Cost of Fans

Table 1 gives the capacity of fans in cubic feet per minute corresponding to pressure in ounces per square inch for three different speeds. The approximate cost of the

TABLE 1. CAPACITY AND COST OF FANS AND BLOWERS

Diameter, In.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	R.p.m.	Pressure, in Oz.	Cu.Ft. per Min.	Cost in Dollars
18	600		2,210	900		3,150	1200		4,080	10
24	500		4,220	800		6,800	1100		9,350	12
25	450	0.25	1,580	907	1.0	3,170	1845	4	6,450	63
30	450		6,384	675		9,650	900		12,846	14
31	365	0.25	2,560	731	1.0	5,100	1488	4	10,390	67.50
36	400		9,600	600		14,600	800		19,200	17
42	270	0.25	5,338	540	1.0	10,670	1080	4	21,390	90
42	350		14,700	550		22,300	750		30,900	20
48	300		18,300	500		30,500	700		42,700	25
54	250		22,100	450		36,000	600		48,500	65
60	189	0.25	10,250	378	1.0	20,490	758	4	41,120	157
60	225		24,750	375		41,000	500		55,000	85
72	200		34,000	300		51,000	400		68,000	120
72	157	0.25	14,840	314	1.0	29,650	631	4	59,490	247.50
84	135	0.25	20,200	270	1.0	40,360	541	4	81,160	315
96	118	0.25	25,060	236	1.0	50,280	473	4	100,440	405
120	94	0.25	37,920	188	1.0	75,790	378	4	152,000	563
132	86	0.25	46,260	172	1.0	92,430	344	4	185,300	630
144	78	0.25	54,400	158	1.0	108,740	316	4	218,080	675

Turbo-Blowers

Size, In.	Boiler Hp.	Cost, in Dollars
15	175	150
18	300	175

fan is also given in each case, and the size is expressed as the diameter of the fan in inches. For sizes of 18 to 48 in. the relation between cost and size is very indefinite, but the approximate cost in dollars, C, may be represented by the equation,

$$C = 0.5\,D + 1 \text{ (lower limit)}$$

in which D is the diameter of the wheel in inches. For sizes of 25 to 60 in. the approximate cost is

$$1.66\,D + 21 \text{ (upper limit)}$$

and for 60 to 132 in.,

$$6.94\,D - 266$$

Effect of Flue-Gas Temperature

Calculations based on a temperature of 60 deg. F. would not be correct for temperatures of 400 or 600 deg., which are common in induced-draft systems. The principles upon which the necessary corrections are made are as follows:

When air is heated it expands, and the weight of a given volume varies as the absolute temperature. The necessary fan speed to produce a given pressure is proportional to the square root of the absolute temperature. The power required to drive a fan varies as the velocity of the flow when the pressure and the outlet area remain constant.

The effects of flue-gas temperature on the speed and capacity of fans are shown in Table 2.

TABLE 2. EFFECT OF FLUE-GAS TEMPERATURE

Temperature of Gases, Deg. F.	Factor for Proportional Volume at 60 Deg. F.	Factor for Increase of Speed	Factor for Increase in Horsepower
400	0.77	1.28	1.28
500	0.73	1.35	1.35
550	0.725	1.38	1.38
600	0.70	1.42	1.42

Editorials

Burning Low-Grade Fuel

The leading article of this issue should be read with more than passing interest. It tells of a moderate-sized plant in which, by simply changing the boiler-furnace equipment, there resulted a saving amounting, in round numbers, to thirty-five thousand dollars per year.

Under the former conditions coal fresh from the mine was burned in the boiler furnaces of the Bessemer Coal & Coke Co. This fuel had a marketable value of about one dollar per ton and one hundred tons was burned every twenty-four hours.

A five to six-in. layer of bone exists between the coal deposits, and it cost from three to four hundred dollars a month to remove this bone from the mine. It had no value as a fuel. When attempts were made to burn it the result was most unsatisfactory.

Six of the power-plant boiler furnaces were recently equipped with mechanical stokers, and now this fuel, that cost something like forty-two hundred dollars a year to remove, is burned under the boilers, with a saving of the run-of-mine coal formerly consumed and a saving in the bone-removal charge. Furthermore, the boiler-room force has been reduced from ten to six men for the twenty-four hours.

This bone contains between thirty and forty per cent. ash content and averages about eighty-five hundred British thermal units per pound as fired. With this fuel and the stoker equipment, the boilers have been operated at one hundred and seventy-five to two hundred per cent. of rating.

There is a lesson in this for the plant that might burn low-grade fuel and does not, and it shows that intelligent investigation into furnace conditions can result in a surprising saving in operating expense as well as, in this instance, the burning of a fuel that was considered worthless. Instances are rare where such great savings can be effected, but it always pays to be vigilant. These people were doing their best under the old conditions, but some one thought of improving the conditions.

Stokers for Locomotives

The summary of a report by D. C. Buell before the annual meeting of the International Railway Fuel Association appearing elsewhere in this issue is interesting as indicating the latent possibilities of the locomotive stoker. What will perhaps come as a surprise to many is the fact that the fundamental reason for the application of stokers to locomotives is that maximum capacity of the engines can be obtained with more certainty under trying conditions than under hand-fired conditions, even with two firemen to a cab. Formerly, the argument for locomotive stokers emphasized the greater economy over hand-firing and the elimination of smoke, just as did the early statements enumerating the advantages of stokers for stationary boilers. Experience seems to be proving that it is the greatly increased capacity possible with a minimum of labor that is the sum and substance of the superiority of stokers for locomotives, just as it is for stationary boilers.

Another quite natural characteristic to be expected is that locomotive-stoker manufacturers have in most, if not all, cases had to adapt their product to the locomotives, but were never frequently favored by designers considering how the locomotive could be made to more favorably receive the stoker. The stoker builders' experience parallels that of the early steam-turbine manufacturers. The turbine, of course, ran too fast, and it was for a long time known that its speed could not be reduced without commercially impossible sacrifices in economy, before builders of "the other end," meaning the driven machine, made serious efforts to adapt their products to turbine speeds.

Engineers may be progressive and radical as they wish, but the fruits of their labors find commercial application only as fast as conservative business permits.

By the way, what is the state of the art regarding stokers in marine practice? Indications are that marine men are going to be true to tradition and not adopt the stoker until its success has been absolutely assured everywhere else.

Welded Pipe Work

The first notable change in steam mains for power plants was the doing away with the double header—the elimination of that emergency steam container considered so indispensable when the header in service developed a serious leak. Plant designers omitted the second header only after experience demonstrated that if the pipe material was sound and the fitting properly done, leaks or steam-main troubles serious enough to warrant cutting out the entire header would not occur. The next advance comes in the reduction of the number of flanges on headers and in mains. A steam leak is not only an eyesore, but makes a sound that disturbs your conscience, drops water down the back of your neck and, unfortunately, costs money. As the leaks invariably occur at the flanges, why have more flanges than necessary?

Autogenous welding has been a great help to various industries, and there are few places in the power plant where it does more lasting good than it does when applied to the heavy piping. As the writer of the article on this subject, appearing elsewhere in this issue, remarks, header and pipe may be made up in lengths limited only by shipping and erecting facilities. In the case of headers the welded header is not only lighter, being more easily supported than a flanged one, but it costs less.

Welding is also proving well suited to pipe-coil construction. Coils are usually inclosed in a shell or vessel, and if a leak occurs, it must be quite serious to be quickly discovered. Welding makes it possible to make up exceedingly long coils with no joints except at the inlet and outlet ends, which are outside the shell containing the coil. Where special bends are needed, the welding process sometimes offers an easy solution to what might be a troublesome problem both in construction and erection.

Quite naturally, considerable apprehension was felt in the early days of the application of welding to high-pressure piping. Many will not permit its application to boilers, and it may be expected that extensive experience with welded steam pipe or the wide dissemination of the results of many destruction tests on welded boilers, will be necessary before the torch will find a field of usefulness on boilers other than cutting old ones into junk and facilitating their removal and transportation to the pile. In this respect the destruction tests described in the article referred to are interesting and encouraging.

Recent License Legislation in Massachusetts

As the smoke of the recent heated discussion of license legislation rises above the good old Commonwealth of Massachusetts, an amended license law is seen to have resulted. Supervision of boilers, inspections and licensing remains in the hands of the boiler-inspection department of the District Police.

Before considering this last amendment a little history of the license-legislation tendency in the Commonwealth during the last few years will assist in more clearly comprehending the causes back of the recent change.

Section eighty-two of the original law stated that "Licenses shall be granted according to the competence of the applicant . . ." Again, Section eighty-one rules that ". . . he shall receive, within six days after examination, a license graded according to the merits of his examination, irrespective of the grade of license for which he applies."

In this law nothing was said about a man holding one grade of license being compelled to serve a specified time before he could apply for one of a higher grade. It was in 1911 that the desires of many for a time-service clause found a place in the law which, as then amended, made it necessary for applicants to have served specified times under lower-grade licenses before they could lawfully apply for licenses of a higher grade.

That part of Section eighty-two relating to special licenses seems to have been objectionable to many manufacturers, particularly those whose plants were run most of the time by water power, but which had steam power for low-water periods or for emergency purposes. The law allowed an engineer a special license for a particular plant, "provided, however, that no special license shall be granted to give any person charge of, or permission to operate, an engine of over one hundred and fifty horsepower." This same section also allows a man holding a second-class license ". . . to have charge of and operate a boiler or boilers, and to have charge of and operate engines, no one of which shall exceed one hundred and fifty horsepower, . . ."

It is seen that a plant having an engine or engines of more than one hundred and fifty horsepower and operated most of the time by water power was compelled to have a first-class engineer in attendance. This, it seems, was the thorn in the manufacturer's side. So this year the much-talked-of House Bill No. 1111, widely circulated with a form letter urging those approving to request their representatives to support the bill, was presented. This bill aimed to overcome the special-license objection by providing that a person desiring to have charge of a particular plant might, on examination, receive a third-class license, which, according to Section twenty-one of the bill, allowed "the holder to have charge of and operate any particular steam engine or engines." The firemen's license would have covered the boiler or boilers.

So much was asked for in Bill 1111 that the proponents suffered the experience of the dog that stopped to look at himself while crossing the brook with a bone in his mouth. A compromise was effected in which the manufacturers are allowed to have engineers holding special licenses to operate plants with engines of any capacity, so long as the plants are run by water power exclusively during the major part of the year.

We see no objection to this amendment, as it does not make these plants more dangerous to public safety than before, provided, of course, that the examiners do their duty. It should ease the strained relations between employers and engineers.

The Plumber and Us

Can it be that the plumber intends encroaching upon the domain of the power engineer?

From a recent issue of the *Plumbers' Trade Journal* it is gathered that there is a growing belief among master plumbers that their future "resembles a broad path of progress leading to the top of contract hill, the apex of which will be reached when the master plumber handles not only the plumbing, but the heating, ventilating, power plant, lighting, elevators, sprinkler equipment and refrigeration work as well."

These are high-sounding words, my masters, and would seem to indicate that the "apex" alluded to is, just at this minute, impossible of discernment. It is reasonable to say, however, that the plumber of today—once a worker in lead and popular mainly as a medium for threadbare witticism—has in many directions so broadened his one-time field of endeavor as to include much inter-related work. He has, for example, become "familiar with the radiant warmth of the heating system"; he is already attracted "toward the power handled by the little copper wire"; his association with boilers has privileged him to talk intelligently on pounds pressure and B.t.u., and his anxious inquiries in his trade papers show his interest to be greatly beyond the use of the soldering iron and the pipe cutter. Furthermore, he informs us that, as "consolidation is the modern trend in every line," he feels that in the future he will "handle" a large, thick slice of the mechanic arts—or cease to exist!

A most confident and ambitious person is the plumber man, as no one will deny. He insists that the sanitary wholesomeness now enjoyed by the public is mainly owing to his efforts, and that in due time his trade will be a profession.

As to his desire to annex the territory, to occupy the terrain, of the powers now controlling the power-plant, the heating and ventilating, refrigeration and elevator domains, one is inclined to the opinion that the plumber in his present state is vainly striving to separate from its main body a huger portion than he can successfully masticate.

Correspondence

Putting Crank Disk on Shaft

On page 654 of the May 11 issue is a letter requesting information on tightening a loose crank without removing it. I believe that it is almost impossible to do this and make a safe job, because after the engine has been run for some time with a loose disk it will not only hammer the hole out of true. but will also deface the surface of the shaft, so that the disk, if made tight, would be out of line. Consequently, the crank would not be true.

There are several methods of tightening a disk, all depending on the conditions, material available and tools at hand. I know of one case where the disk was riveted onto the shaft, and another where the shaft and the disk were drilled, reamed and tapped to receive tapered bolts at several points on the shaft. In the latter case the disk was out of line, although it was run for some time by leaving the crankpin brasses keyed slightly loose. This caused a slight pound, which increased until the tapered bolts became loose and hammered, so that they could not be removed. Eventually, a new shaft and crank disk had to be purchased. So it is cheaper in the long run to put on the new disk first and see that the shaft end is in proper condition before the disk is put on, or it may be necessary to rig a turning tool and means for revolving the shaft to true up the battered end before the disk is fitted.

The cause of many a loose crank disk is in the heating before it is placed on the shaft. In most cases where the job is to be done a long way from the shop, the disk is blocked up on brick supports with a fire beneath it. In many instances the fire is too hot and the flame will concentrate through the hole in the center of the disk, causing the edge around the hole to become very hot, perhaps a bright-red heat before the rest of the disk shows signs of turning red at all. This is where the mistake is made in judging the temperature which the metal should stand at the edge of the hole without ruining its contracting quality, causing it to crush together or stretch when the shaft is expanding from the heat of the disk. This is owing to the fact that the outside edge of the disk is usually much cooler and does not expand as the shaft does, and the metal around the hole, being hotter, is compressed, thus causing a misfit when cold. The fire should be a slow one and very even, and a cover should be placed over the hole to prevent the heat concentrating on the inner surface and edges. The disk should then heat gradually and evenly to a very dull or cherry red and no hotter. Even though it may be a little harder to draw on the shaft, it will contract to a good tight fit when cold.

The space in which the metal is compressed while hot extends back to a circle about one inch larger than the bore for the shaft and the pin cannot be made tight without removal and refitting, often by refitting and reshrinking over a shim or bushing. When the keys are not the proper size to fill the keyways in the shaft and hub, small steel strips should be made to fit on top of them to prevent the key from working up or down and wearing out the sides of the slots, which will happen with a loose disk or wheel, though it may not be noticed at the front or face of the hub.

I had an experience with a crank disk that had been overheated at the bore. This was to be put on a 650-hp. cross-compound engine just being erected. The job was a time contract, and the engine had to be ready or penalties would be exacted. The time was short and it was urgent that the disk be put on before dark, as there was no light to work by. It was heated over a roaring hot fire, and overheated at the center, but it went on nicely. The engine was assembled, tightened up and adjusted and ran smoothly with normal load. When the overload was put on, however, the trouble was discovered—the low-pressure disk had loosened, the bore had battered about $^1/_{64}$ in. out of true, and one would have thought there was 4 ft. play judging from the hammering before the engine could be stopped. A new disk was sent from the shop, but in the meantime, to avoid loss of time and penalty, it was decided to try calking the boss of the hub around the shaft. This held the disk tight enough for normal load, but only contracted the metal in the hub to a depth of ½ in. or less in the 6 in. of the disk's thickness and would have given way again as soon as load enough was put on the engine to bring extra strain on the disk. Greater precaution was taken in heating the next disk and it went on the shaft nicely and gave no trouble.

R. A. CULTRA.

Cambridge, Mass.

Replying to Mr. Jensen's letter, it was a mistake to have the keys fit tight sideways. If he will pull these and substitute keys made with side clearance, which are tight top and bottom, driving home with a 20-lb. sledge, he will have no further trouble. In preparing the new keys have them made with heads to facilitate pulling during the process of fitting, which will require some care. After driving home, the heads can be cut off. The keys, being tight at the top and bottom, pull the crank to practically a forced fit on the opposite side of the shaft.

JOHN F. HURST.

Louisville, Ky.

I would suggest that Mr. Jensen take out the old keys and replace them with new ones properly fitted. Do not try to use up the old keys by placing liners in with them, as this is only a makeshift.

Making keys grip on the sides of a keyway is a method much used by machinists in this country. Why, I do not know. The proper way to fit a key is to have it large enough so that when first driven in it will go only about three-eighths of the way. It is then driven out and the high spots filed off. The bottom of the key does not require to be filed, and the sides should merely touch.

Repeat the operation, driving in and out until the key reaches within 3/4 in. of being home, then use a heavy sledge for the final drive. The key is driven flush. Should any part project, chip off and file. If it has been properly fitted there will be no more trouble.

This is the method I have used on the wheels of locomotives after they had been shrunk on, and were not beaded over. The sketch did not show whether the keyway is extended beyond the crank disk to allow the driving out of the keys, but if not and there is room, it will be necessary to do so, just enough to allow the key drift to enter.

C. Sword.

Cohoes, N. Y.

In regard to Mr. Jensen's loose crank disk, I would advise drilling and tapping five tapered holes, half in the disk and half in the shaft, then screwing in tapered bolts very tightly. Cut these off flush and peen the shaft evenly all around so as not to throw it out of line. Take time and pains with this job.

B. C. White.

Yonkers, N. Y.

[Letters covering many of the points mentioned were received from William Braunbeck, of New Brighton, Penn., and James E. Noble, of Toronto, Can.—Editor.]

Cost of Handling Ashes With Steam Vacuum System

In the article describing the boiler plant of the Union Brewing Co. in St. Louis, which appeared in the May 18, 1915, issue of Power, the paragraph on page 665 referring to the cost of handling ashes is rather ambiguous. We are in a position to know that the 10 to 12c. was intended as the total cost per ton, including the charge for steam. A casual reading might give the impression that the 10 to 12c. included only the fixed charges, such as depreciation, interest, etc. Since the article was written we have had an opportunity to inspect one of our systems that has been handling ashes at the rate of 60 tons per day, and from the results of this inspection we are confident that the main pipe will handle at least 100,000 tons before it is ready for the scrap heap. Taking a small plant producing 10 tons of ashes per day, or 3000 tons per year of 300 days, as a typical example, we have found that the cost for repairs has amounted to $8.50, or $0.00285 per ton. Figuring the initial investment at $1000, interest at 6 per cent. would amount to $60 per year, or 2c. per ton. At the rate of 3000 tons per year, the equipment would last for 33⅓ years, or in round numbers, say 30 years. The depreciation then could be figured at 3⅓ per cent. and this proportion of $1000 amounts to $33.33 per annum, or $0.01111 per ton. Summing up, the charges for upkeep, interest and depreciation amount to $0.03396, or approximately $0.034. To this must be added a charge of about 6c. per ton of ash for steam, making a total of $0.094 per ton, which figure may be compared to the 10 to 12c. given in the article.

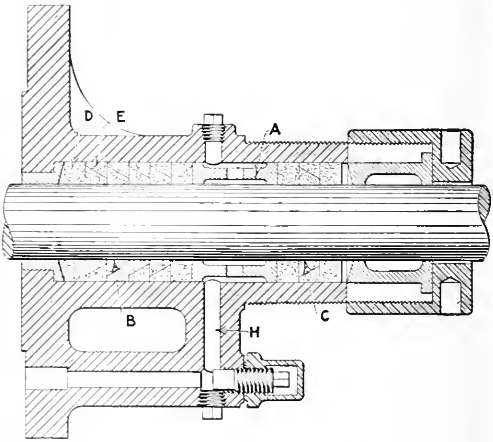
Ordinarily, in a plant handling 10 tons of ashes per day, no additional labor would be required to operate the vacuum system, but to meet all contingencies the following comparison may be of interest: Where 10 tons of ashes per day are handled by hand over a distance of 100 ft., the cost is rarely below 20c. per ton, or a total cost of $2 per day. Assuming this charge per ton for wheelbarrow conveyance and also as a labor charge for the vacuum ash-handling system, which would handle the total amount of ashes in 2 hours, the charge against the latter would be only 40c. as compared to the $2 given above. Adding the $0.94 for the other items entering into the cost of the vacuum system gives a total of $1.34 for the 10 tons. Without allowing anything for the equipment that would be needed in hand conveyance, the saving is 66c. per day, or $198 per year of 300 days. On this basis the earning is nearly 20 per cent. on the investment, so that in a little over five years the equipment would pay for itself. At the end of this time the saving would be much larger, as the interest and depreciation items would have been eliminated.

R. H. Miller,
Girtanner-Daviess Engr. & Contr. Co.

St. Louis, Mo.

Ammonia Stuffing-Boxes

The ammonia-pump piston rod is usually made of hard hammered steel and frequently separates from the steam piston rod. The reason for this construction is apparent. The pump piston rod wears rapidly, and if the machine



Stuffing-Box of Ammonia Compressor

is fitted with a two-piece piston rod the pump rod may be replaced when worn without disturbing the steam rod.

A long stuffing-box, as shown, is divided into two compartments by the gland *A*. In packing an ammonia stuffing-box care must be taken that this gland is over the port *H*, leading to the suction of the pump. With a box constructed in this way the first set of packing *B* is subjected to cylinder pressure. Any leakage past this packing is reduced to suction pressure at once, thus the second set of packing *C* is only subject to this pressure. The port *H* should always be kept clear. This port can be closed by means of the plug and the space about the gland filled with oil to act as a seal, if desired.

When the stuffing-box is properly packed with alternate plain (*D*) and sectional (*E*) rings, as shown in the sketch, there is no necessity for subjecting the packing to great pressure to keep the box tight. If the rod is worn it should be removed at once and turned true, or if this is impracticable a new pump piston rod should be installed.

It is impossible to properly pack the stuffing-box when the rod is badly worn.

THOMAS J. ROGERS.

Brooklyn, N. Y.

Gasoline Engine Run on Natural Gas

In answer to the inquiry of Mr. Gawthrop as to the feasibility of using an automobile engine on natural gas, I believe the results would not be satisfactory.

Last year in Texas, I ran upon a similar proposition. In this case the engine was taken from an old Buick car and was belted to a 15-kw. alternating-current generator. The engine was provided with a Pickering governor, bolted to the crank case and belt driven from the crankshaft. The governor stem, through levers, handled the gas and air butterfly valves. We found that it was necessary to arrange the valve levers so that, for a given movement of the governor stem, the air valve moved through a greater angle than did the gas valve. This was owing to the fact that on light loads the mixture became too lean to explode if the two valves regulated to the same degree.

The outfit ran fairly well, although it was necessary to watch it constantly and it required far more attention than did the 100-hp. gas engine in the plant. The amount of lubricating oil used was excessive, as the engine, although in excellent condition, tended to heat up after a three- or four-hour run. While it was impossible to check the consumption with any degree of accuracy, it was the belief of the operators that the gas per horsepower was at least 50 per cent. greater than in the regular gas engine.

As regards the speed regulation, on a fairly steady load the lights did not flicker and the voltage fluctuation was small. However, when the load dropped off suddenly the engine would speed up considerably, in which case the engineer would run to change the gas-valve link rod, thereby bringing the speed back to normal.

No gasoline engine will burn natural gas economically unless means be provided to increase the compression, such as fitting new cylinder heads. If this is not done, the amount of gas used is excessive. For any given cylinder dimensions an engine will develop approximately five-eighths as much power on gas as on gasoline, in ordinary operation. Consequently, the 60-hp. automobile engine should develop about 50 hp. at 1000 r.p.m. or 37.5 hp. at 750 r.p.m.

Mr. Gawthrop, in using a 17½-kw. generator, would require not more than 27 hp. Therefore, his engine need never deliver more than 65 per cent. of its rated capacity. At this load he will do well to obtain a horsepower-hour on less than 25,000 B.t.u., or 50 per cent. more than a regular gas engine would use at this percentage of full load (17,000 B.t.u. at 60 per cent. load.) A standard-make gas engine at full load will ordinarily develop a brake horsepower-hour on 11,000 to 12,000 B.t.u. If the outfit develops 27 b.hp., the additional heat required would be 351,000 B.t.u. per hour, which, based on a six-hour run, would be 2,106,000 B.t.u. daily. Not knowing the gas used, one can merely estimate its heat content. Assuming 800 B.t.u. per cubic foot, the autombile engine will demand 2630 cu.ft. per day more than the gas engine. If gas costs 25c. per thousand cubic feet, the extra fuel consumption of the automobile engine would be about $240 yearly. Of course, the lighting load will vary, so that the 27 hp. will probably be the maximum rather than the normal load. Nevertheless, the gas consumption will be at least as much as given above, since on any smaller load it will be still more per horsepower-hour. Therefore, it would probably be cheaper to purchase a gas engine, thus also avoiding the worry, trouble and extra fuel expense that he will undoubtedly experience with his automobile engine.

L. H. MORRISON.

Fremont, Neb.

With reference to Mr. Gawthrop's inquiry, page 654, May 11 issue, as to the use of a gasoline engine on natural gas, I would advise him to increase the compression about 25 per cent. either by putting plates on the piston or cylinder head or by employing a new piston to fill up the extra clearance. Plates on the piston head are not satisfactory owing to the weight. He will need a heavier flywheel also. If operated without the above, and, as on gasoline, the engine will develop from 40 to 60 per cent. of its former power.

B. C. WHITE.

Yonkers, N. Y.

Uniform Size for Catalogs

I should like to call the attention of manufacturers and dealers to the desirability of uniform-sized catalogs. The writer, like many others, likes to file by subject, and catalogs are very awkward to handle as they are now issued. One large heating concern issues a number of publications, and no two of them that I have seen are of the same size.

This looks like a small matter, but filing catalogs for reference would be much more conveniently done if the advertisers saw the matter as it appears to the user of the catalogs.

LEWIS F. BROWN.

Winston-Salem, N. C.

The Storage Battery and Its Limitations

The storage battery as a power-plant auxiliary is looked upon by some engineers as objectionable, because of the constant and skillful care required. The writer believes, however, that there is no electric apparatus that responds so readily to good care as the storage battery, and it can be watched easily by means of a hydrometer and voltmeter, as well as by the gassing during overcharge. Where a battery set is properly installed in a clean and well-ventilated place, heated in the winter to approximately 70 deg. F., and is properly cared for and worked in accordance with its capacity, it will repay the owners in more ways than one.

The present lead sulphuric-acid battery appears to reach its all-around maximum usefulness on the 220-volt system, or less. Most batteries in power stations are installed for emergency or standby service and depend mostly on ampere-hour capacity for maximum usefulness. To increase the voltage above 220 means increasing the number of cells, and proportionately increasing the cost to keep the ampere-hour capacity the same. Consider a 220-volt and a 550-volt railway system and a proposed 2000-ampere-hour battery. The initial cost of the former will be less than half that of the latter, which also holds true as to maintenance. In order to keep down the initial cost of the 550-volt railway battery, the ampere-hour capacity is often sacrificed, leaving a train of troubles behind that are not easily remedied, especially with increasing load. In cases where it is possible to shut down a few hours each night, a storage battery for lighting purposes and light loads can be made to pay for the investment by keeping the load factor higher on the generating set, with a saving in coal and oil and a chance for small repairs during shut-down periods.

BEN DAWSON.

Cedar Rapids, Iowa.

Broken Corliss Exhaust Valve

On our 42x60-in. Allis blowing engine, from some unknown cause the bottom exhaust valve broke at the eye where the stem fits in. We had no spare valves, and to avoid a loss of several hundred dollars a day, a rapid repair was necessary. The broken piece was clamped back

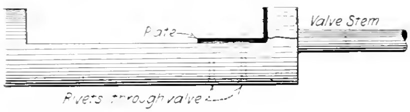


FIG. 1. EXHAUST VALVE REPAIRED

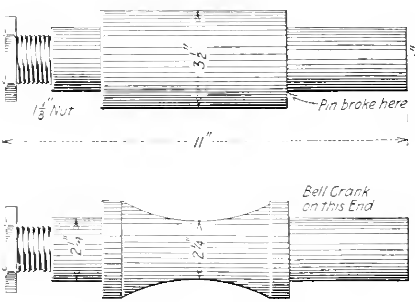


FIG. 2. DASHPOT PIN, SIZE REDUCED

in place temporarily, a plate was bent into the shape shown, and drilled and riveted to the valve. The stem was then put in and holes were drilled through stem and valve and countersunk. The parts were then riveted together and smoothed off to make a running fit, Fig. 1, and the engine was started five hours after the accident.

On a 96-in. low-pressure blowing engine with a Corliss valve gear a lot of trouble was caused by the breaking of the dashpot pins. Different kinds of material were used without success, the pins lasting from six weeks to three months only. A change was finally made, as shown in the illustration, Fig. 2. Instead of making the pin straight across, some of the metal was turned out, which made it much lighter and gave it a chance to spring a little. After this change, the pins lasted from six to twelve months.

FRED K. GINTHER.

Leetonia, Ohio.

Facing up Rubber Pump Valves

When pump valves become worn they have to be faced up or replaced with new ones. The usual way of facing by hand, using sandpaper on a block of wood having a true face, requires considerable work, time and sandpaper.

The pump I have in mind has 24 valves costing $1 each, so they cannot be thrown away when they begin to leak. The rig I use for facing the valves is made from a square block of wood held in the lathe chuck and turned down to the size of the disk, and the extreme end to the size of the hole in the center of the valve to act as a guide. Four brads, driven in and pointed so as to sink into the back of the valve, hold it from turning while facing. In this way old valves are made serviceable for a long time.

R. G. CURREN, JR.

Kittanning, Penn.

A Pipe Stopper

An arrangement used by plumbers for the same purpose as that described in the issue of May 25, on page 724, is made in the following way. It consists of a ¾-in. pipe with a long thread on one end, over which is screwed an iron washer about one inch smaller than the inside diameter of the pipe to be plugged. Next to this washer a cup leather is placed, then a smaller washer, and a ¾ locknut.

The outer end of the pipe is connected to the water service. When the stopper is inserted into the pipe beyond the riser and the water is turned on, the pressure will open out the cup leather and prevent any water passing it. A set of leather and iron washers for each size of waste pipe will make it possible to clear almost any line about the place.

JAMES E. NOBLE.

Toronto, Ont.

Removing Dents from Tanks, etc.

Frequently, tanks, pipes and floats of metal become dented, which is objectionable in one way or another, and the dent cannot be got at from the inside. There are two ways of getting rid of the dents; one is by heating and the other is by hammering externally. The former method is preferable for very thick tanks. The heat should be applied around the depression so that the metal on the borders will be heated and expanded, and then at suitable intervals the dented portion should be cooled. This will keep contracting and drawing the dented part back into place. An easier method for thinner articles consists of tapping around the edges of the dent with a light hammer, which will bring the dent out. Neither process is quick, but both are effective.

A. P. CONNOR.

Washington, D. C.

Inquiries of General Interest

Butt Joint with Single Cover Plate—For a boiler shell, what advantage over a lap joint has a butt joint with a cover plate on only one side?

T. H. R.

With a single cover plate, the cover behaves simply as an intermediate plate attached to the two main pieces by an ordinary lap joint, and unless the cover plate is of sufficient thickness to prevent its bending, a butt joint has no advantage over a lap joint.

Air-Supply for Ventilation of Assembly Rooms—What quantity of air-supply is regarded as adequate for good ventilation of assembly rooms?

R. G.

The requisite air-supply by ventilating apparatus will depend largely upon the character of building construction and the period for which the rooms are occupied. For ordinary conditions the average quantities recommended by authorities as a minimum quantity of outdoor air which should be supplied per room occupant per hour may be stated as follows:

For theaters, 1200 cu.ft.

For factories, workrooms, courtrooms and auditoriums, 1500 cu.ft.

For school and college rooms, 1800 cu.ft.

Reversing Eccentric with Same Angle of Advance—If the eccentric of an engine with direct-connected valve gear is set so that it has an angular advance of 28 deg. and it is desired to change the direction of rotation of the engine, how far and in what direction should the eccentric be moved to obtain the same angle of advance with the engine reversed?

J. B.

Angular advance of 28 deg. signifies that the eccentric is $90 + 28 = 118$ deg. ahead of the crank, and for opposite direction of rotation with the same angle of advance, the eccentric should be turned back 118 deg. on the other side of the crank; or, what would be the same thing, the eccentric might be turned $360 - (2 \times 118) = 124$ deg. forward in the first direction of rotation of the shaft.

Chimney Crack From Expansion of Lining—What causes a crack to form all around a brick chimney at about three-fourths of its height? The crack developed after the chimney had been in use only a short time and reappeared after it had been repointed.

A. H. W.

In construction, the core or lining has undoubtedly been incorporated with the outer walls at a point above the crack, and from expansion of the lining from heat the upper portion of the shell has been raised from the lower portion. By driving steel wedges in the crack at a time when the lining is at highest temperature the core, upon cooling, may separate itself from the shell and cause no further trouble after repointing the outside. The surest remedy would be to remove the upper portion of the stack down to a point where the lining can be stopped off and rebuild the exterior in such a manner that it will not be affected by the expansion of the lining.

Properties of Nickel Steel—How is nickel steel made, and how does its strength compare with that of simple steel?

C. S.

Nickel steel is made by adding metallic nickel, nickel ore or ferro-nickel to the bath of the openhearth process. The finished product usually contains 3 to 4 per cent. nickel, about 0.3 per cent. carbon, 0.7 per cent. manganese and 0.02 per cent. phosphorus. The presence of nickel decreases the corrosiveness and increases the density and strength of the steel. On account of its high elastic limit and toughness, nickel steel is well adapted to resistance of sudden stresses and shocks. As compared with simple steels of the same tensile strength, a 3-per cent. nickel steel has about 15 per cent. higher elastic limit and about 25 per cent. greater elongation, and as compared with simple steels of the same carbon, the nickel steel up to 5 per cent. nickel has about 40 per cent. greater tensile strength with practically the same elongation and reduction of area.

Quality of Steam by Separating Calorimeter—In using a separating calorimeter the graduated glass gage on the instrument showed that the calorimeter in a given time had collected 0.15 lb. of water, and during the same time there was 2 lb. 14 oz. of condensate of the dry steam added to the condensing water. What was the quality of the steam?

W. C. H.

Where W represents the weight of water that the calorimeter separated from the steam, and W_1 represents the weight of dry steam condensed after separation, then the total weight would be $W + W_1$ and the quality q, or dryness, would be represented by the formula,

$$q = \frac{W_1}{W + W_1}$$

As $W_1 = 2$ lb. 14 oz. $= 2\,^{14}/_{16}$, or 2.875 lb., and W = 0.15 lb., then by substitution,

$$q = \frac{2.875}{0.15 + 2.875} = 0.954, \text{ or about 95 per cent.}$$

Size of Pump—With 50 ft. of piston speed per minute, what diameter would be required for the piston of a pump to supply 140 gal. of water per min., allowing 7 per cent. reduction of displacement by slippage and piston rod?

C. W. O.

Allowing 231 cu.in. per gal. and for the reduction of capacity by slippage and piston rod, the required gross displacement would be

$$\frac{140 \times 100}{100 - 7} \times 231 = 34{,}774+ \text{ cu.in. per minute,}$$

which for a piston speed of 50 ft. per min. would require a piston having

$$\frac{34{,}774}{50 \times 12} = 57.95 \text{ sq.in. of area}$$

which corresponds to

$$\sqrt{\frac{57.95}{0.7854}} = 8.59,$$

or about 8½ in. diameter.

Starting Torques of Motors—How do the starting torques of series- and shunt-wound direct-current motors compare with those of squirrel-cage and wound-rotor types of alternating-current motors?

C. H. R.

The starting torque of a series motor may be several times the full-load torque, the torque increasing much more rapidly than the current or nearly as the square of the current, until magnetization approaches saturation, when it varies more nearly as the current, the maximum torque being at the minimum speed. In a shunt-wound motor the starting torque varies directly as the current and may be 2 to 2¼ times the full-load torque. In a squirrel-cage motor full-load torque requires several times the full-load current, hence this type of motor is not adapted for use where a heavy starting torque is required. A wound-rotor type induction motor will start under full-load torque with little more than full-load current, and with a high-resistance rotor the starting torque can be increased beyond the full-load torque.

Air Required for Combustion of Gas—What number of cubic feet of air is theoretically required for the combustion of a cubic foot of gas consisting of 75 per cent. CH_4, 20 per cent. C_2H_6 and 5 per cent. C_3H_8?

N. C. I.

In formation of the products CO_2 and H_2O the volumes of O_2 from the atmosphere will be required in the proportions of

$$CH_4 + 2\,(O_2) = CO_2 + 2\,H_2O,$$

0.75 of a cubic foot requiring $2 \times 0.75 = 1.5$ cu.ft. of O_2;

$$2\,C_2H_6 + 7\,(O_2) = 4\,CO_2 + 6\,H_2O,$$

0.20 of a cu.ft. requiring $^7/_2 \times 0.20 = 0.7$ cu.ft. of O_2; and

$$C_3H_8 + 5\,(O_2) = 3\,CO_2 + 4\,H_2O,$$

0.05 of a cu.ft. requiring $5 \times 0.05 = 0.25$ cu.ft. of O_2. That is, combustion of 1 cu.ft. of the mixture requires

$$1.5 + 0.7 + 0.25 = 2.45 \text{ cu.ft. of } O_2.$$

As oxygen contained in air constitutes 20.92 per cent. of its volume, then as 4.78 cu.ft. of air will be required to furnish 1 cu.ft. of oxygen, the 2.45 cu.ft. of oxygen needed for combustion of 1 cu.ft. of gas will require $4.78 \times 2.45 = 11.71$ cu.ft. of air.

Distribution of Heat in Gas-Engine Cylinder*

By A. H. Gibson and W. J. Walker

An experimental gas engine recently installed in the engineering laboratories at University College, Dundee, appeared to afford exceptional facilities for an investigation into the cylinder losses. This engine, built by the National Gas Engine Co., Ltd., has a cylinder diameter of 11 in. and a stroke of 19 in., and the connecting-rod may be lengthened so as to vary the compression ratio between the limits 5.17 and 6.62. Governing is on the hit-and-miss principle. A special feature is the arrangement of the cylinder jacket in two parts—one surrounding the exhaust valve and that portion of the exhaust passage included within the cylinder casting, and the other covering the breech end and barrel of the cylinder. The jacket water is led in series through the two sections, its temperature being measured before and after passing through each. The heat attributed to jacket losses in a gas engine having the usual arrangement of jackets includes a certain amount which, correctively, should be attributed to exhaust losses. In the engine under consideration the magnitude of these two sources of loss can be ascertained with much greater accuracy.

In order to measure the heat contained in the exhaust gases after leaving the cylinder, an exhaust cooler was fitted to the exhaust branch. In this cooler the temperature of the gases was reduced by their passage over a series of 33 tubes, each ⅝ in. outside diameter and 4 in. long. The jacket water passed through these tubes on its way to the cylinder jackets, and its temperature was measured before and after passing through the cooler.

The trials were carried out with a view to determine how the distribution of heat through the engine varies with the speed of the engine, the brake horsepower, the compression ratio and the richness of the mixture.

The normal speed of the engine is 200 r.p.m., but in the trials a range of speeds from 140 to 260 r.p.m. was examined. The maximum brake horsepower depends on the speed and mixture, its values being approximately as follows:

Air Ratio—(Vols.) Gas	Speed, R.p.m.		
	150	200	250
7	25.0	31.5	36.0
9	20.0	25.0	28.5
11	16.5	20.5	23.5

In the trials the brake horsepower was varied from zero up to this full-load capacity. Three different compression ratios were adopted—5.17, 5.70 and 6.62—and three different air-gas mixtures were used—7 : 1, 9 : 1 and 11 : 1. In individual trials of the same series the richness of the mixture varied by not more than 5 per cent. on each side of the mean, and in the majority of cases the variation did not exceed 2 per cent. either side.

Town gas was used, having an average analysis of: CO_2, 3.8 per cent.; O_2, 1.1 per cent.; CO, 13.0 per cent.; CH_4, 26.3 per cent.; C_2H_4, 4.7 per cent.; H, 38.0 per cent.; N, 13.1 per cent. The gas supply was measured by a dry meter, and its mean lower calorific value, which was used in all calculations, was 520 B.t.u. per cu.ft The air-supply was also metered.

Systematic analyses of the exhaust gases were carried out, mainly with a view to insuring that combustion was complete before the end of expansion. In no case was more than a trace of combustible found in the gas, and in the majority of cases no trace was found.

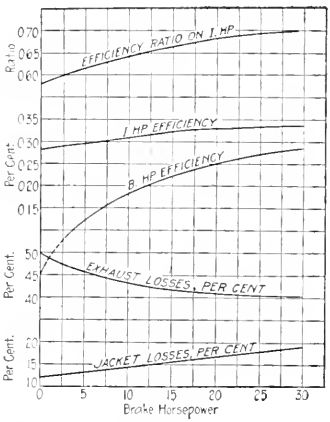


Fig. 1. Performance with a 5:17 Compression Ratio; Air: Gas = 9:1, and 200 R.p.m.

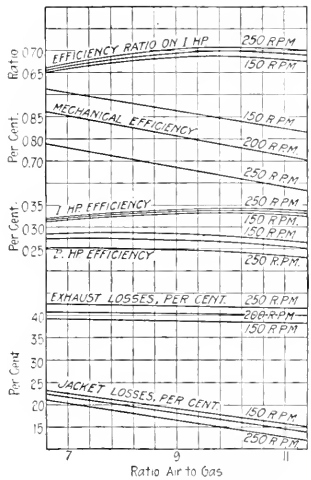


Fig. 2. Full Load with a Compression Ratio of 5:17

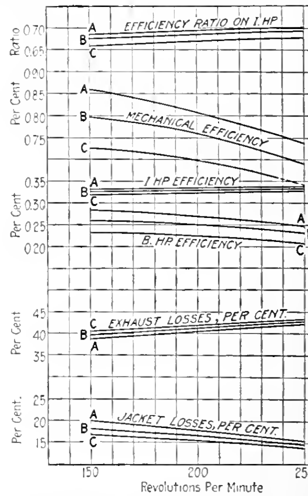


Fig. 3. Compression Ratio = 5:17; Air: Gas = 9:1. Curve A at Full Load Curve, B at .8 Load, Curve C at .6 Load

Of the total heat in the exhaust gases leaving the cylinder, part was absorbed by the water in the exhaust-valve jacket and part in the exhaust-gas cooler. The latter was not sufficiently large to cool down the gases to atmospheric temperature, and their temperature on leaving the cooler was between 200 and 300 deg. F. The heat carried away by these gases was estimated from a knowledge of their weight, specific heat and temperature.

From the data obtained, a series of curves was plotted, and by interpolation from these curves the more important data corresponding to speeds of 150, 200 and 250 r.p.m. and to brake horsepowers of 10, 15, 20, 25 and 30 were deduced for each gas mixture and for each compression. The main results of the investigation may be summarized as follows:

The mechanical efficiency increases with increasing load, diminishes as the ratio of air to gas increases (Fig. 2), diminishes as the speed increases (Fig. 3) and is sensibly independent of the compression ratio (Fig. 4). The maximum efficiency attained in these trials, namely, at full load with the richest (7 : 1) mixture and at the lowest speed (150 r.p.m.), was 88 per cent. At the normal speed of 200 r.p.m. and with the same mixture, the efficiency was 85 per cent., while with this same speed and the weakest (11:1) mixture, it fell to 76.7 per cent.

*From a paper read before the Institution of Mechanical Engineers, May 14, 1915.

The thermal efficiency, as measured on the indicated horsepower, increases with the load (Fig. 1), attains a maximum with an air-gas mixture of approximately 10 : 1 (Fig. 2), increases slightly as the speed increases (Fig. 3), and increases as the compression ratio increases (Fig. 4). The maximum thermal efficiencies attained were as follows:

Compression ratio		5.17	5.70	6.62
		Efficiencies		
Speed	150	33.1	34.4	36.5
	200	33.9	35.3	37.4
	250	34.4	35.8	37.9

As measured on the brake horsepower, the thermal efficiency increases with the load (Fig. 1); attains a maximum with an air-gas ratio of 8 : 1, that is, with a richer mixture than gives maximum indicated efficiency (Fig. 2); diminishes as the speed increases (Fig. 3), and increases with the compression ratio (Fig. 4). The maximum efficiencies based on the brake horsepower were:

Compression ratio		5.17	5.70	6.62
		Efficiencies		
Speed	150	27.9	29.1	31.0
	200	27.5	28.6	30.2
	250	25.7	26.7	28.3

Adopting the air cycle as the standard of comparison, the ideal efficiencies corresponding to the various compression ratios were:

Compression ratio	5.17	5.70	6.62
Air cycle efficiency	0.482	0.501	0.532

The ratio of the actual thermal efficiency, measured on the indicated horsepower to the corresponding air-cycle efficiency, increases with the load (Fig. 1), has a maximum value when the ratio of air to gas is approximately 10 : 1 (Fig. 2), increases slightly with the speed (Fig. 3), and is sensibly independent of the compression ratio (Fig. 4). At full load and with the most efficient air-gas mixture, the relative efficiencies were, for all compressions:

Revolutions	150	200	250
Efficiency ratio	0.687	0.700	0.709

The exhaust losses, in per cent., diminish as the load increases (Fig. 1), diminish very slightly as the ratio of air to gas increases (Fig. 2), increase as the speed increases (Fig. 3), and diminish as the compression ratio increases (Fig. 4). At full load the exhaust losses in these trials were between 33.6 and 42.5 per cent. The former value corresponds to a weak mixture, high compression and low speed, and the latter to a rich mixture, low compression ratio and high speed.

The percentage of heat carried away by the water flowing through the cylinder jackets, not including the exhaust-valve jacket, increases with the load (Fig. 1), diminishes as the ratio of air to gas increases (Fig. 2), diminishes as the speed increases (Fig. 3), and is sensibly independent of the compression ratio (Fig. 4).

Since at 150 r.p.m. the period of contact per cycle, of hot gases and cylinder walls, is 1.66 times as great as at 250 r.p.m., the rate of heat transmission through the cooling surfaces is evidently much greater at the highest speed. An examination of the indicator diagrams, moreover, shows that the maximum pressure and temperature attained in the cylinder are approximately 6 per cent. greater at 150 than at 250 r.p.m., so that this increased rate of transmission is obtained in spite of a lower gas temperature. The reason is apparently to be found in the fact that the greater turbulence of the working fluid at the higher rates of speed increases its effective conductivity to an extent which more than counterbalances the effects of a smaller temperature difference and a shortened time of contact. Other things being equal, a 6-per cent. increase in the temperature of the gases would probably increase the heat transmitted by conduction and radiation by some 15 per cent., so that it may be taken approximately that the effective conductivity is increased in the same ratio as the speed of the engine.

The radiation loss diminishes as the load increases, increases as the ratio of air to gas increases, diminishes as the speed increases, and increases slightly as the compression ratio increases. At full load, radiation accounts for between 5 and 14 per cent. of the heat given to the engine, the former value obtaining with a rich mixture, high speed and low compression ratio and the latter with a weak mixture, low speed and high compression ratio.

DISTRIBUTION OF HEAT UP TO END OF EXPANSION STROKE

Since part of the heat carried away by the jacket water passes into the cylinder walls after release, this should, in a true heat balance, be credited to the exhaust. The item attributed to radiation represents heat lost by radiation from the hot exposed surfaces of the piston and of the unjacketed portion of the breech, and from the outer surface of the jackets. Although this loss is wholly due to heat flow through the walls, only part of this flow takes place during the expansion stroke. The remainder, occurring after the end of this stroke, is also to be attributed to the exhaust.

Thus in a heat balance drawn for the working fluid up to the end of expansion, the apparent heat flow into the walls is to be increased by the greater part of this radiation loss and to be diminished by that part of the heat transmitted to the jacket water during exhaust. Similarly, the apparent exhaust losses are to be increased by some small part of the radiation loss and by that part of the heat given to the jacket water during exhaust. The net result is that both the wall losses and the exhaust losses, as given by direct measurement, are to be increased by some unknown proportion of the radiation loss.

The results indicate, in general, that of the total radiation loss obtained by difference from the heat measurements a proportion ranging from about 0.33 to 0.40 is to be added to the apparent exhaust losses, the remainder going to increase the

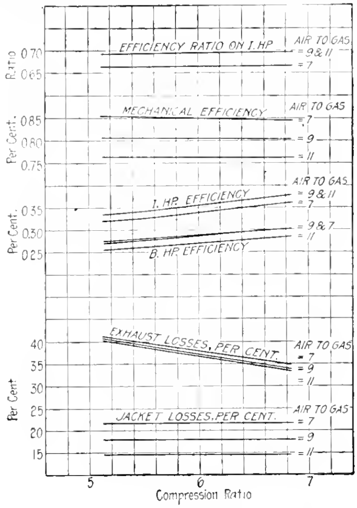


FIG. 4. FULL LOAD AT 200 R.P.M.

apparent jacket or wall losses. This proportion reaches its highest value with the highest compression ratios and with the richest mixtures.

A comparison of these with results obtained in a similar manner by Hopkinson on a slightly larger engine, shows a fairly close agreement. In round numbers the figures are as follows:

	Air/Gas = 10.8		Air/Gas = 8.1	
	Hopkinson	Authors	Hopkinson	Authors
Heat as i.hp.	37	36	33	35
Heat in exhaust	42	41	39	39
Heat flow to walls	21	23	28	26

The heat entering the exhaust-valve jacket ranges from 8 to 12.5 per cent., being the greatest at low loads, low speeds and with low compression ratios and rich mixtures. If this be added to the cylinder-jacket loss, it gives the loss as determined from trials of an engine fitted with the usual arrangement of jackets.

Under favorable circumstances it appears that a heat balance sheet obtained by measuring the indicated work and jacket heat of a commercial type of engine, and by estimating exhaust losses by difference, is in extremely close agreement with the balance sheet based on the internal energy of the gas at the end of expansion. For fairly rich mixtures and lower compression ratios the measured jacket losses are, however, always in excess of those more correctly computed from the internal energy of the gas.

Hydrogen Was Discovered or isolated in 1766 by Cavendish, an eccentric English chemist, who called it "inflammable air," but the French chemist, Lavoisier, named it hydrogen, meaning "water former." Nitrogen was also identified as a constituent of air at about the same date as oxygen and hydrogen (1766 to 1774) and named nitrogen by Chaptal, because of its existence in niter.

Illinois N. A. S. E. State Convention

The eleventh annual meeting of the Illinois State Association, N. A. S. E., held in Decatur, May 26-28, proved to be one of the best in the history of the organization. Business was attended to promptly by the engineers, exhibits were good, and the entertainment was lively from beginning to end. Good fellowship prevailed and the close coöperation between the engineers and the exhibitors contributed largely to the success of the convention. The first session opened promptly Wednesday morning at the St. Nicholas Hotel, with W. H. Jennings chairman of the local committee, presiding. After the opening prayer by Rev. C. E. Jenney, Mayor Dan Dinneen made an address of welcome, to which Fred W. Raven, national secretary, responded.

Dr. G. E. Fellows, president of Millikin University, of Decatur, in an interesting address on education, referred briefly to the educational work of the organization, and then turned to the broader aspect of his subject and showed how education was correlated with the advancement made by the human race. Up to 150 years ago the people thought that they needed a king to do their thinking for them and tell them what they must do. France was the first country to give the people the opportunity to rule themselves and to allow them freedom of thought and action. Most of the advancement made has been since that time. The greatest thing that ever happened to this country was the act signed by Abraham Lincoln setting aside grants of lands in the various states, which made possible the state universities and provided higher education for the people at large. For the past thirty years serious attention has been given to industrial education, and during this time more progress has been made than in all the previous years. It is evident, then, that progress and advancement are largely dependent on education.

In his response, John Lane, editor of the "National Engineer," contended that it was a general mistake to confound education with teaching. Schools teach men, but they must educate themselves. If they cannot retain or apply what they have learned, then the teaching is useless. The man who can apply what he does know to the best advantage, whether learned in college or in practice, will make the most progress and be of the most use to the community.

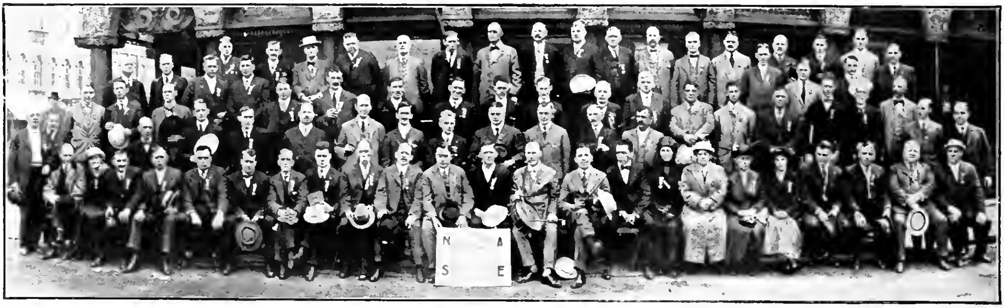
After a brief talk by Charles Cullen, president of the Central States Exhibitor's Association, W. E. Hill, state president, was formally introduced and the meeting was officially opened. The usual committees were appointed and the session adjourned.

The afternoon was spent in a trip to the Wabash locomotive shops. A large number of engines were being overhauled, and the work proved to be of exceptional interest. For the benefit of the visitors a locomotive weighing 78 tons was raised from the floor, moved a distance of 50 ft. and lowered upon the wheels placed for it, in five minutes. The placing of the engine was so accurate that it was not necessary to move it to the right or the left as it was lowered in position.

In the evening State Deputy Henry Misostow delivered an address at a special meeting of exhibitors and engineers. His topic was "Efficiency," of which there were two kinds, one sensible and the other commercial. The former created more for the same expenditure of energy. Employees were treated as men and encouraged to use their brains in performing their duties. In the other system men were made into machines and their efficiency based on the amount of their work. There should be no distinct demarcation between engineers. Any engineer can be as good as any other provided he puts as much energy into his work and puts forth the same amount of effort to become efficient. Many men look at the man above them admiringly and think, "He is better than I." This admission should never be made until the same effort has been exerted to become efficient. At the close of the address Messrs. Hickey, Tilley, Thompson, Fiske, and the famous quartet gave an excellent and thoroughly enjoyable performance.

At the business session Thursday morning there were 32 accredited delegates from 13 associations out of 17 belonging to the state organization. In his report President Hill stated that two new locals had been added in the past year and one of these had joined the state association. The president spoke highly of the work of the educational committee. Secretary Anderson reported a net gain of 43 members, which was a little over 3 per cent. of the total number affiliated with the state body. John S. Alt, chairman of the legislative committee, reported that license and inspection laws similar to those in force in Massachusetts and Ohio had been presented to the state legislature, and by compromising on the boiler pressure and the square feet of radiation requiring a licensed engineer, it was thought that the chances were excellent for the bill to pass at the present sitting of the legislature. The compromises thought necessary were to raise the boiler pressure from 10 to 20 lb. and to increase the radiation from 5000 to 20,000 sq.ft.

In the afternoon the engineers were taken through the Decatur High School and shown the annual exhibit of the pupils. In the auditorium of the school they listened to an interesting lecture by Prof. G. E. Goodenough, of the University of Illinois, on the development of the steam tables and on the properties of saturated and superheated steam. The professor gave briefly the leading events in the development of the steam tables, reviewing the work of Regnault, Callendar, Knoblauch and Linde, Davis, Peake and Grindley and other authorities who had contributed to the work. By means of charts he compared the results obtained by these various experimenters and calculators. He commented on the accuracy of their work and in curve form presented the results obtained from a formula he had developed after a careful consideration of all the data that had been previously given on the subject.



DELEGATES AT ILLINOIS N. A. S. E. STATE CONVENTION

In the evening delegates and visitors were entertained at the exhibitors' hall, with a theater party sandwiched in between. The ball game scheduled between the engineers and supplymen for Friday morning was called off on account of rain. At the last session on Friday afternoon, Henry Mistele, of Milwaukee, one of the national trustees, talked on the good of the order, referring particularly to education and the most effective medium for education the association possessed—"The National Engineer." He asked the engineers to support their paper and spoke of the value of the advertising section. Peoria was chosen as the next convention city, and the following officers were elected: Henry Misostow, state president; Charles Scott, vice-president; G. R. Anderson, secretary-treasurer; W. E. Hill, state deputy. "Dad" Beckerleg installed the officers, and the convention adjourned for another year.

The exhibits were up to the usual standard, the following firms being represented: The V. D. Anderson Co., Crandall Packing Co., Dearborn Chemical Co., Edward Valve & Manufacturing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Garlock Packing Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., "National Engineer," Peerless Rubber & Manufacturing Co., Wm. Powell Co., "Power," Madison-Kipp Lubricator Co., H. Mueller Manufacturing Co., National Boiler Specialties Co., Perolin Co. of America, The Screiber Perfect Boiler Skimmer & Cleaner Manufacturing Co., Standard Oil Co.

Mechanical Stokers for Locomotives

Before the seventh annual convention of the International Railway Fuel Association, held in Chicago, May 17-20, the committee on firing practice, D. C. Buell, chairman, presented an interesting report on mechanical stokers as applied to locomotives. A brief summary follows:

The original conception of a mechanical stoker for locomotives contemplated the adoption of the stoker on a fuel-economy basis. The claims were based on the fact that the stoker supplied coal to the fire uniformly and according to the single-scoop method; that it overcame the necessity of opening the fire-door and the consequent cooling effect in the firebox and that it avoided the production of black smoke. The introduction of larger and heavier power, together with the desire to work this power to maximum capacity on low-grade lines where continuous firing is necessary, has brought about a new problem. The amount of coal necessary to burn per hour to keep these locomotives working at full capacity is such that there has been a demand for two firemen on all locomotives weighing over 185,000 lb. on the drivers.

The real economy of the stoker is in the increased tonnage that can be handled by stoker-fired locomotives—not in the saving of fuel, as seems to be the general impression. The large, mechanically fired locomotives are able to handle more tonnage than the same locomotives would be given if hand-fired, and they handle this tonnage at a higher speed and with greater certainty than under hand-firing conditions. The development of the stoker has made possible the development of locomotives designed to burn coal continuously at a rate in excess of the capacity of the ordinary fireman to supply it, so that the real reason for the improvement and adoption of the mechanical stoker is found in the economic necessity of reduced operating costs. Other causes giving an incentive to stoker development are the possibility of increasing the capacity of locomotives already in service and the possibility of using cheaper fuel on such locomotives.

There are three companies now manufacturing locomotive stokers commercially; and in addition, the Pennsylvania Lines West of Pittsburgh have developed the Crawford stoker and applied it extensively to their own locomotives. According to the most reliable figures obtainable on Apr. 1, 1915, there are 935 locomotives equipped with stokers, which are distributed between twenty different lines of railroad.

There seems to be no fixed factor that can be used as a sure guide as to the size of the locomotive that would warrant the installation of a stoker. One report indicates that any locomotive of 200,000 lb. total engine weight, with cylinders of 22 in. or over should be equipped with a stoker. A second report states that engines having a tractive effort of 50,000 lb. or over, should be stoker-fired. It seems to be the consensus of opinion, however, that locomotives should be hand-fired when the coal consumption for an extended period does not exceed 4000 lb. per hr. It is the general belief that the stoker will give about 10 per cent. increased tonnage capacity as compared with hand-firing under the same conditions as to grade and time, although some reports indicate that the tonnage increase will be more. Stoker-fired engines will make better time with the same tonnage on the same grade than hand-fired engines, and there will be a saving on the basis of the amount of coal burned per thousand ton-miles. This is due to the fact that additional tonnage may be handled by stoker-fired engines with about the same gross amount of coal as with hand-fired engines.

The meat of the whole stoker problem is, that increased tonnage can be handled. If increased capacity of locomotives is desired, then stokers are economical. If maximum evaporation is what is required on large engines, its attainment may result in a sacrifice of tonnage capacity. A number of other advantages were given, such as reduction of smoke and spark loss. The first cost of the stoker installation is between $1500 and $1700. Maintenance cost including interest on the original investment, is anywhere from ½ to 1c. per mile. This item is more than counterbalanced if a cheap grade of fuel is used with the stoker.

Briefly summarized, the results of the use of locomotive stokers are as follows: The stoker is over 90 per cent. efficient. A six months' record of the use of stokers on the Norfolk & Western R.R. shows an efficiency of 97½ per cent. Roads having a considerable number of stokers in service show a performance of over 50,000 miles per engine failure on stoker-fired locomotives. It seems conservative to state that the stoker will show a satisfactory fuel economy based on ton-mile performance; that is, while it may not show a reduction in the gross amount of coal consumed per trip, it will show that it can haul more tonnage, using about the same gross quantity of the same or a cheaper grade of fuel, than a hand-fired engine. From the coal producer's standpoint, the increased demand for slack coal and screenings for stoker-fired engines will be of benefit. The stoker obviates the necessity for two firemen on large engines. No complications are introduced in the way of detention at terminals, engine failures on the road, or in connection with the smoke-elimination problem. To sum up, the stoker, even in its present state of development, pays in every case where real stoker jobs are indicated.

Looking into the future, the development of the stoker makes possible and practical the design of larger locomotives. In fact, engines have been purchased within the last two years and are being built today which would neither have been purchased nor built had it been necessary to have them hand-fired. Particular reference is made here to the large decapod, mallet and triplex engines. So far, manufacturers have been compelled to adapt their stokers to existing locomotives. It is safe to say that in the future the design of large locomotives will contemplate the application of a stoker, and the design will be modified as may appear necessary to insure convenient, economical and successful application of correspondingly modified and improved stokers.

Central-Station Conditions

The general conditions of the central-station industry are reviewed by T. C. Martin, in his annual report on progress to the National Electric Light Association. While the industry has suffered to some extent by the general business depression, and has not maintained the normal rate of increase, still the outlook is encouraging. Figures from 65 per cent. of the companies indicate that for the second half of 1914 there was an increase in earnings of at least 5 per cent. The combined operating revenue of the Brooklyn system, for example, showed a gain for 1914 of 10.5 per cent.; the gross earnings of the Providence system increased 9.25 per cent. over the preceding year, and new business showed a gain of 18.7 per cent. The Pacific Gas & Electric Co.'s gross earnings for 1914 were about a million dollars greater than in 1913, and the Detroit-Edison system showed a gain of 11.1 per cent. The gross earnings of the central-station industry as a whole in 1914 are estimated in excess of 375 million dollars. This is in addition to the lighting and power work done by street-railway systems.

The yearly peaks and load factors of the leading systems for 1914 were as follows:

System	Peak Load in Kw.	Date of Peak Load	Yearly Output in Kw.-Hr.	Yearly Load Factor Per Cent.
Niagara Falls Power Co.	131,520	Jan. 5	906,513,620	78.7
Ontario Power Co.	130,500	Sept. 23	781,664,400	68.4
New York Edison Co.	229,787	Dec. 23	719,193,535	35.7
Pacific Gas & Electric Co.	124,000	Oct. 29	658,298,000	60.6
Penn. Water & Power Co.	74,000	Dec. 17	277,200,000	42.5
Philadelphia Electric Co.	77,728	Dec. 1	250,697,952	36.8
Boston Edison Co.	65,342	Dec. 21	194,137,400	34
Brooklyn Edison Co.	49,300	Dec. 9	153,946,900	35.6
Commonwealth Edison Co.	306,200	Dec. 15	1,114,130,000	43.6

Apparently, the diversity of the loads along the Atlantic seaboard did not vary greatly, since the annual load factors of the Boston, New York, Brooklyn and Philadelphia companies are not far apart. The Pacific Gas & Electric Co., however, with its greater territory and greater diversity of load, shows a much higher load factor, as do also the Ontario Power Co. and the Niagara Falls Power Co.

OBITUARY

Samuel C. Midlam died on June 2 at the age of 83 in New York. He served in the navy during the Civil War, was chief engineer of the old United States Man-of-War "Otsego" when that vessel was sunk in Albermarle Sound, and also served on the old "Atlanta" and the gunboat "De Soto." After his retirement from the navy, nearly thirty years ago, he entered the service of the Hudson River Day Line. When he retired last year as chief engineer of the Day Line steamer "Albany," he was said to be the oldest engineer in the United States, in point of age as well as service.

Hydro-Electric Plants in New England are producing more than 2,000,000,000 kw.-hr. of energy, which, if produced by coal, would mean the annual consumption of 3,000,000 tons of that fuel, according to figures given by Henry I. Harriman, president of the Connecticut River Power Co., in an article in the "General Electric Review."

PERSONALS

E. A. Thompson has resigned as smoke inspector of the City of Baltimore and will take up consulting and efficiency engineering, with offices at the Hansa House, Charles and German Sts., Baltimore.

Myron J. Bigelow, formerly mechanical engineer with the Molyneux Mailing Machine Co., Buffalo, N. Y., has opened a consulting engineering office, with headquarters at 47 Hawthorne St., Akron, Ohio.

ENGINEERING AFFAIRS

The American Boiler Manufacturers' Association will hold its annual convention at the Lawrence Hotel, Erie, Penn., June 21-23. One of the most important matters to be considered is the means of securing the adoption of the A. S. M. E. Boiler Code by the several states. J. D. Farasey, East 37th St. and Erie R.R., Cleveland, Ohio, is secretary.

The National Association of Master Steam and Hot Water Fitters will hold its twenty-seventh annual convention June 21-24, at the Hotel Wisconsin, Milwaukee. An attractive program has been arranged, and the coöperation and active support of all members are requested to make this the most successful convention in the association's history.

The American Supply and Machinery Manufacturers' Association held its annual convention at the Bellevue-Stratford, in Philadelphia, June 3 and 4. A number of excellent addresses were made on topics vitally concerning the business of the members, notably an address on "The Power Problem," by C. M. Ripley, and an address on "Fundamental Business Conditions," by P. F. Bryant, of Wellesley Hills, Mass. The entertainment features included a vaudeville-smoker and a dinner-dance.

The New England Association of Commercial Engineers, 308 Equitable Building, Boston, Mass., has selected the new building now under construction at the corner of Oliver and Franklin St., and will use the basement and first two floors as an exhibit, while the upper floors will be used for a meeting room and lecture hall for the several engineering organizations and mechanical societies and for offices. It is thought that the whole building will be occupied by those interested in the machinery and power-equipment field. It is expected that the exhibit will be opened on Oct. 1 in the new building. Mr. Lewis L. Warren is manager of the exhibit.

The American Iron & Steel Institute held its eighth general meeting on May 28 at New York. The following papers were presented: "Blast Furnace Advancement," by Andrew E. Maccoun, superintendent, Edgar Thomson Blast Furnaces, Carnegie Steel Co., Braddock, Penn.; "Merchant Rolling Mills," by Jerome R. George, chief engineer, Morgan Construction Co., Worcester, Mass.: "The Commercial Production of Sound and Homogeneous Steel," by Edward F. Kenney, metallurgical engineer, Cambria Steel Co., Johnstown, Penn.; "Waste-Heat Boilers," by Charles J. Bacon, steam engineer, Illinois Steel Co., South Chicago, Ill.; and "Recent Progress in Corrosion Resistance," by Daniel M. Buck, metallurgical engineer, American Sheet & Tin Plate Co., Pittsburgh, Penn.

The National Association of Manufacturers held its annual meeting May 25 and 26 at New York. The sessions were devoted mainly to legal and economic questions. The convention adopted the report of the Committee on Fire Prevention, stating that full coöperation between state legislators, insurance companies and property owners, and the spending of more money by municipalities and legislatures for fire prevention were the best means for reducing the enormous waste of the nation's resources. The convention, through the Committee on Accident Prevention and Workmen's Compensation, held that mechanical safety devices can prevent but a small percentage of accidents, while the large majority must be prevented by education, organization and individual caution, with emphasis upon individual caution. The Industrial Betterment Committee rendered a preliminary report on the legislative minimum wage, concluding that such legislation was not wanted by employees or employers and had been unsatisfactory to both, and that undesirable industrial conditions could best be improved through practical education and by stricter legal supervision.

BUSINESS ITEMS

The Homestead Valve Manufacturing Co., Desk D, Pittsburgh, Penn., is conducting a prize name contest, offering $50 cash as a prize for a suitable name for a new gate valve.

E. W. Swartwout, formerly of the Chicago office of the Nordberg Manufacturing Co., Milwaukee, Wis., will hereafter be associated with Mr. McLaren, in the New York office of the company. Enlarged offices have recently been taken in the new Equitable Building, 120 Broadway, New York. The Chicago office will be in charge of John E. Lord.

James Beggs & Co., manufacturers of the Blackburn-Smith feed-water filter and grease extractor and the Beggs sewage ejector system, have opened offices in Saginaw, Mich., and Cleveland, Ohio. Their representatives at these points will give prompt attention to inquiries received from the State of Michigan and the northern part of the State of Ohio, respectively.

The "S-C" Regulator Co., Fostoria, Ohio, has established the following branch offices: Chicago, Ill., 1535 Lytton Building, in charge of L. K. Deckerson and E. H. Bolton; New Orleans, La., 315 Carondelet St., George Keller; Atlanta, Ga., 702 Candler Building, E. F. Scott; Charlotte, N. C., 1213 Realty Building, James E. Weinhold. In Birmingham, Ala., the company will be represented by the McClary-Jemison Machinery Co.

The Berwind-White Coal Mining Company, Windber, Penn., recently ordered twenty-six 2½-in. Simplex "Seatless" blow-off valves from the Yarnall Waring Co., Chestnut Hill, Philadelphia, Penn. The interesting feature of this order is that it makes the fifth repeat order as a result of a six-months' trial of two valves shipped Feb. 11, 1914. The Corrigan-McKinney Co., Cleveland, Ohio, has recently ordered 56 of these 2½-in. valves.

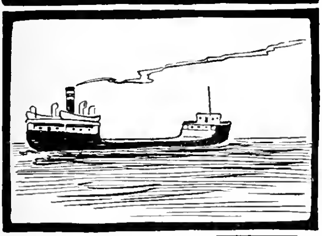
The Terry Steam Turbine Co., Hartford, Conn., has appointed Merton A. Pocock as district sales manager for the territory included in Minnesota, North Dakota and South Dakota. His office is 400 Endicott Building, St. Paul, and this arrangement supersedes the company's previous selling agreement with Robinson, Cary & Sands Co., of St. Paul. The company has also appointed the Hawkins-Hamilton Co., Peoples National Bank Building, Lynchburg, Va., as representatives for Virginia.

The Diesel-type engine manufactured by the McIntosh & Seymour Corporation, of Auburn, New York, will in future be sold in the Texas and Oklahoma territory through the agency of Arthur G. Wright, 209 Slaughter Building, Dallas, Texas. This appointment excludes that portion of Texas west of a line drawn north and south through Del Rio. Mr. Wright's extensive experience with the machinery business and particularly with all types of power plants, renders him a valuable consultant to those who are considering new installations, and his advice may be sought by all interested parties.

Among the orders recently received for Venturi meters by the Builders Iron Foundry, Providence, R. I., are the following: H. C. Frick Coke Co., Pittsburgh, Penn., three 4-in. meter tubes with Type M register-indicator-recorders; Union Bag & Paper Co., Woolworth Building, New York City, one 4-in. meter tube with Type M register-indicator-recorder; John B. Mallers, Chicago, Ill., one 3-in. meter tube with Type M register-indicator-recorder. All these meters are for boiler-feed service. The West India Management & Consultation Co., 129 Front St., New York City, has ordered for the Trinidad Sugar Co. two 2½-in. meter tubes and Type M register-indicator-recorders for the measurement of maceration water. The company has also received two orders for meter tubes for the measurement of air—one from the Combination Engine & Compressor Co., Bradford, Penn., for a 2-in. meter tube and manometer to be used in the testing of air compressors, and one from Purdue University, Lafayette, Ind., for a 4-in. meter tube.

POWER

Vol. 41 — NEW YORK, JUNE 22, 1915 — No. 25



Purposeful Anecdotes

A true plain story of the success of a plugger—to encourage those who think only the gifted or lucky win out.

° ° °

A Life Story

HERE is the condensed history of an engineer. With self-respect and a little determination, so he declares, anyone can do as well or better.

He was taken from school before he was 10 years old. For five years he worked at plumbing, but did not like it. Then he worked four years at steam and hot-water heating, attending night school during two of these years.

Next, he became an assistant engineer on a lake steamer. At this time he started to study engineering books and journals. At 21 years he secured a situation as an apprentice in a large factory.

Next, he was the engineer in a large modern hotel, after which he went with the Canadian General Electric Co. as trouble man in its Peterboro works. The Ontario Government offered him a situation as stationary engineer, and he accepted.

At present he holds a position with the Canadian Government as chief engineer in a large plant and has a staff of sixteen men. Incidentally, he has received altogether several hundred dollars in the past few years for contributions on engineering, etc., to technical papers. He describes himself as only an ordinary man, by no means smart or clever, but he is temperate and has never been afraid to do a little extra work with no extra pay.

He has been down-hearted more than once and even wrote to Power for advice some years ago and he received encouragement in reply. Power has this engineer's address.

Norfolk & Western Electrification

SYNOPSIS—Power for the electrified section of 30 miles is supplied by a 30,000-kw. steam plant at Bluestone Junction and five substations. Generation is at 11,000 volts three-phase, transmission at 44,000 volts single-phase and the trolley voltage 11,000 single-phase; step-down transformers and phase-converters on the locomotives transform the current for use in three-phase induction motors. Regenerative braking is employed.

The electrified section of the Norfolk & Western Ry., known as the Elkhorn grade, is located on the main line in the southern part of West Virginia and extends from Bluefield to Vivian, a distance of about 30 miles. This is a switching and short-haul division between the coal fields and Bluefield, operated to a large extent independently of the other traffic on the main division. In addition to the heavy-tonnage coal-train service, however, freight and passenger traffic over this section is also handled in part by electric locomotives, which are used as pushers on the steep grades. The purpose in electrifying this section was to increase the capacity by materially reducing the time required to handle traffic and to provide a more economical and efficient service over the heavy grades. The heavy freight trains are handled with electric locomotives at a running speed up the grades of 14 miles per hour, as compared with 7½ miles under steam operation. Further saving in time is effected by the elimination of the delays occasioned by the steam engines occupying the tracks while taking on coal and water at several places on the grades. Moreover, one electric engine takes the place of two Mallet steam locomotives over the division, or two electric engines take the place of three Mallets up the grades and at practically double the speed.

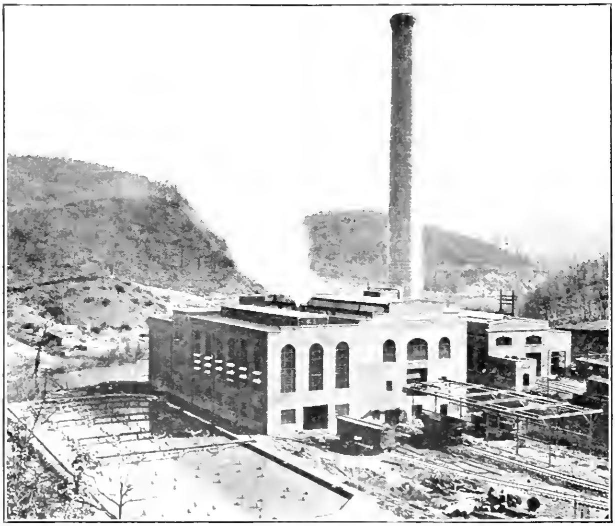


Fig. 1. Power-Plant Building and Spray Pond

The transmission and distribution system is single-phase at 25 cycles, and power is collected from the overhead catenary at 11,000 volts. The locomotives, however, are equipped with phase-converters which, in connection with step-down transformers, change the single-phase current of the trolley to three-phase for use in the three-phase induction-type traction motors. Thus, while retaining all the advantages of high-voltage, single-phase distribution and collection, the advantages of three-phase induction motors for the heavy traction service is also secured.

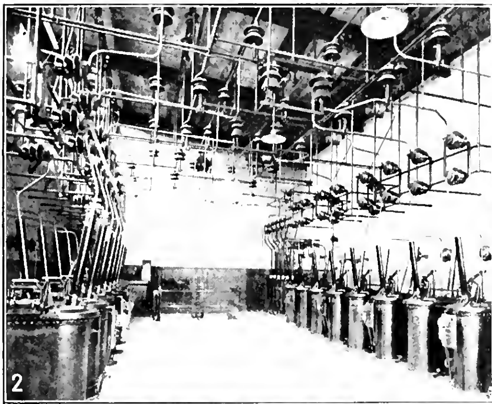
Another important feature of the employment of polyphase induction motors for traction is the electric braking of the trains at constant speed while descending grades. This not only utilizes the energy of the moving trains to drive the motors as generators and thus return energy to the line, but also permits the heaviest train to be handled down the mountain grades with a single engine at a uniform speed of about 15 miles per hour, while the air brakes are held in reserve for bringing the train to a stand-still when necessary.

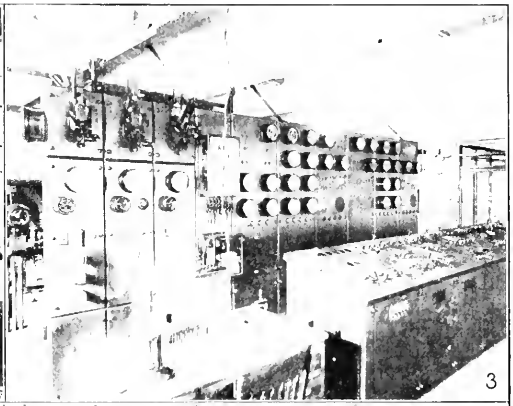
The Power Station

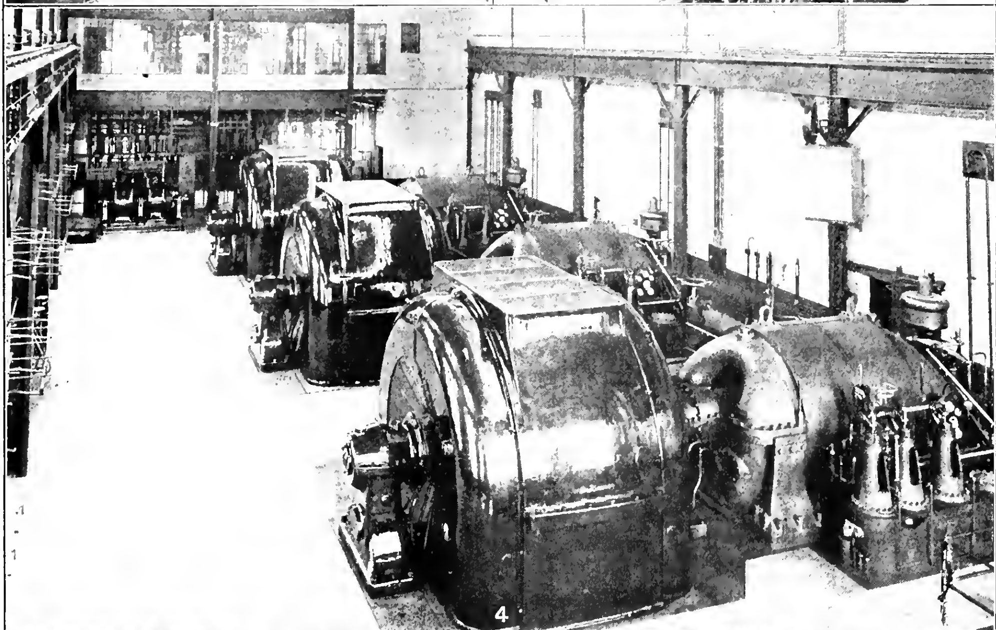
The power station was located at Bluestone, on the Bluestone River, mainly for the reason that this is practically the only available source of water for boiler feed and condensing purposes in the district, and the company had already constructed a dam and reservoir here for the water supply for the steam locomotives. The main building contains a boiler room 79x158½ ft., and a turbine room 56x158½ ft. Across the east end of the latter a section 26 ft. wide is assigned for the switching equipment, offices and other facilities and is fitted with intermediate floors and galleries. On the main floor is the low-tension switching room, separated from the turbine room by a heavy wire screen; the next floor is the operating gallery overlooking the turbine room. On the ground floor of the extension building are the step-up and step-down transformers, and on the second floor is located the high-tension switching apparatus.

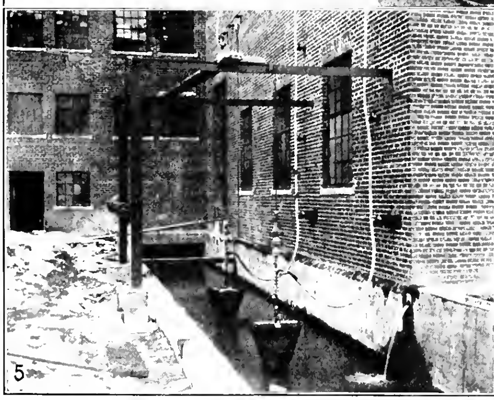
Coal and Ash Handling

Coal is received in hopper-bottom cars on a siding along the south side of the station, the cars discharging into a steel hopper under the track. Below the hopper is a single-roll crusher which empties into an inclined conveyor of the bucket type having a capacity of about 60 tons per hour, at a speed of 80 ft. per min. This elevates the coal to a hopper at the east end of the boiler-room monitor, and from this hopper the coal is fed to a horizontal distributing conveyor extending longitudinally









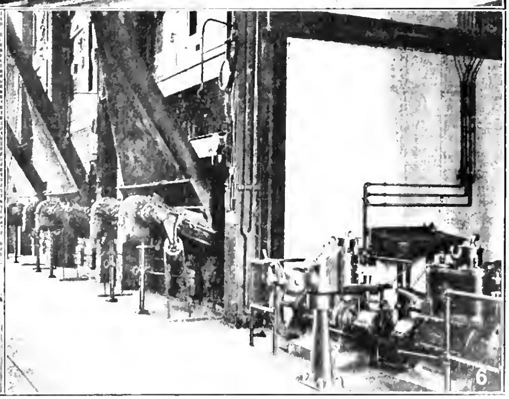


Fig. 2. High-Tension Switching Room. Fig. 3. Control Board. Fig. 4. Turbine Room. Fig. 5. Regenerated Power Loading Rheostats. Fig. 6. One Side of Boiler Room

over the boiler room. Coal is distributed by means of nine handwheel-operated gates to two storage bins having a capacity of about 350 tons. The coal-handling machinery is driven by alternating-current motors.

Ashes are discharged through the ashpit hoppers to steel platform cars each carrying two 1-cu.yd. buckets. These are run outside the boiler-room basement to a loading trolley, the buckets being lifted from the platform cars and emptied into gondolas by means of a traveling electric hoist. The hoist motors are 220-volt direct current.

Boilers and Stokers

The boiler plant comprises ten Stirling-type water-tube boilers arranged in two rows with an aisle between. Space is provided for four additional boilers. They are designed for a working pressure of 225 lb. gage and 150 deg. superheat. Each is fitted with an underfeed stoker of sufficient capacity to evaporate 61,000 lb. of water per hour into steam at 200 lb. gage and 150 deg. superheat when supplied with feed water at 200 deg. Each row of stokers is driven by two automatic steam engines, and the stokers are capable of developing 300 per cent. normal boiler rating when burning coal having a heat value of 12,250 B.t.u. Steam from the exhaust header is discharged into two horizontal Cochrane feed-water heaters, each capable of heating 225,000 lb. of water per hour from 40 to 225 deg. F.

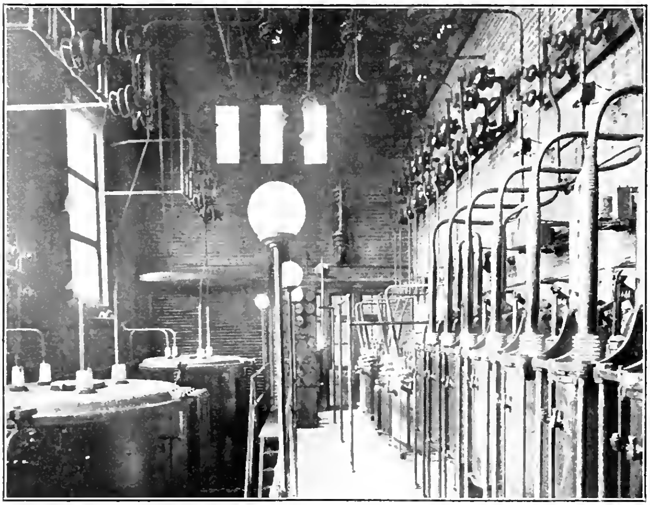


Fig. 7. Interior of Substation

The feed water is taken from the intake canal and pumped to the heaters by two low-head pumps of the horizontal volute single-stage double-suction type having a capacity of 650 gal. per min. against a head of 45 ft. These pumps are driven by 20-hp. steam turbines. From the heaters the water flows to the two boiler-feed pumps which are also of the horizontal volute three-stage double-suction type, designed to operate against a working head of 600 ft. These are driven by 175-hp. steam turbines.

The Stack Details

The stack is of the radial-brick type, 268 ft. in height, or 250 ft. above the grate, with a minimum inside diameter of 20 ft. A 4-in. brick lining extends 75 ft. from the bottom of the flue opening, with a 2-in. air space between the lining and the column.

The forced-draft installation in the boiler-room basement consists of three Sturtevant multivane fans, driven by steam turbines through 4 to 1 herringbone reduction gears. The rated capacity of each fan is 150,000 cu.ft. of free air per minute against a static pressure of 6 in. of water when running at 540 r.p.m.

Steam-Turbine Equipment

The initial equipment consists of three main generating units with space provided for a fourth. These are of the horizontal Westinghouse type rated at 10,000 kw., with steam at 190 lb. gage and 150 deg. superheat when operating at a 28½-in. vacuum and 1500 r.p.m.

Each turbine is equipped with a Le Blanc condenser, and injection water is taken from the tunnel that runs under the basement floor. The condenser injection water and air pumps are driven by a horizontal turbine. The air pump discharges into the intake canal and the injection pump into a pipe leading to the spray-cooling pond. Each condenser is capable of maintaining a vacuum of 28 in. when condensing 145,000 lb. of steam per hour, with cooling water at 70 deg. F. The exhaust steam from the turbines driving the condenser pump is automatically admitted to the main turbines when the supply of exhaust steam is more than is required for feed-water heating. The water from the circulating pumps of all the condensers is discharged into the cooling pond. If the supply of river water is low and not suitable for boiler use, the water is sprayed into the pond and then discharged into the intake canal. If there is sufficient cold river water of suitable quality, the water from the condensers is not sprayed, but is discharged into the pond, from which it is allowed to flow into the river reservoir several hundred feet below the intake and circulates up the stream to the intake, the complete circuit being about 1400 ft. At the west end of the pond is a sluice gate opening into two 36-in. pipes which discharge into the river some distance below the power station. As the normal level of the river is about 3 ft. below the bottom of the pond, the basin may be drained by the sluice gate if necessary.

The Steam Piping

The main steam header runs the entire length of the boiler room on the turbine-room side. It is of 12-in. flanged-steel pipe, and is fed by 8-in. lines from the boilers. Each boiler has an automatic nonreturn stop and check valve, and each turbine is fed by a 12-in. line from the header. Expansion is cared for by long radius bends. All straight lengths of main and auxiliary steam piping are of full-weight wrought steel with van stone extra heavy steel flanges, and all bends and offsets of the main and auxiliary steam lines are of extra heavy steel, the exhaust-steam piping up to 10 in. in diameter being of merchant pipe with standard-weight screwed cast-iron flanges, the bends and offsets of extra heavy pipe and standard-weight cast-iron flanges. All exhaust lines of 12-in. diameter or over are of cast iron with standard-weight fittings.

The piping is covered with 85 per cent. magnesia blocks 1½ in. thick, the smaller live-steam pipes having one layer and the larger ones two layers. The exhaust and low-pressure piping is covered with air-cell sectional blocks of asbestos paper finished with rosin-sized paper and canvas, as in the case of live-steam piping.

Generator Installation

The main generators have a rating of 10,000 kw. at 80 per cent. power factor, 11,000 volts, 25 cycles, single-phase. At this rating they are specified to operate 24 hours, with a rise in temperature not exceeding 60 deg. C. above the temperature of the cooling air. This temperature rating is used because the load factor and form of the load curve are such that a rating on this basis gives a truer conception of the size of plant required than would be obtained by adhering to the usual temperature basis of rating machines operating on a high load factor. The armatures are wound three-phase, the traction load being taken off one-phase only and the auxiliary motors around the power house running off the three-phase bus. This of course necessitates a much larger machine for the given output, but has certain advantages over the use of single-phase generators.

Each generator is ventilated by a blower with a capacity of 50,000 cu.ft. of air per minute against a static head of 5 in. of water, the fan being driven by a 100-hp., 440-volt, three-phase motor. The blowers are located in the basement.

There are two turbine-driven and one motor-driven exciters. They are compound-wound machines with commutating poles and each has a capacity of 600 amp. at 250 volts. Voltage regulation is effected by a Tirrell regulator.

Power for signal service is applied by two turbine-driven generators, supplying 60-cycle, single-phase, 4400-volt current.

Turbine Oiling System

Oil is pumped from a Bowser filter to storage tanks having a capacity of 3000 gal. and located 32 ft. above the turbine floor. From the tank it flows by gravity to the turbine oiling system, consisting of a water-cooled reservoir from which the oil is pumped from the governor and the bearings by a gear-driven pump operated from the turbine shaft. The oil is supplied to the governor at a pressure of 45 lb., which is reduced to about 10 lb. by a reducing valve before passing to the bearings. From the bearings it returns to the cooling reservoir.

Switching Apparatus

The generator leads connect through oil switches with a three-phase, 11,000-volt bus which is sectionalized, three-phase power for the auxiliary services being taken off the island section. Power for the railway service is taken off one phase only, as previously stated. This phase connects with three 5000-kv.-a., 11,000 to 44,000-volt transformers, the secondaries being connected to 11,000 single-phase feeders. The secondaries of these transformers have their middle points grounded through resistance.

No brick or concrete busbar compartments are used. Instead, the bus structure consists of copper tubing carried on insulators mounted on pipe framework. Copper tubing and bare wire are used wherever possible, insulated wire being employed only where the conductors are carried in conduits. All the oil circuit-breakers are electrically controlled from the operating gallery, the control being from the auxiliary direct-current busbars or a storage battery located in the turbine-room basement.

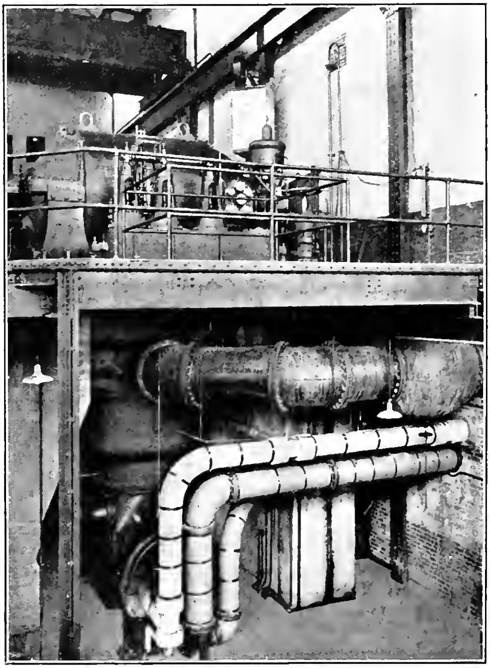


Fig. 8. Le Blanc Condenser under Turbine

Regeneration Loading Rheostats

Excess regenerated power returned at no load passes to the 11,000-volt bus and through the various transformers back to the generators if they are running under very light load or no load. If no other load were provided, the regenerated power would reverse the generators and operate them as motors. To prevent this, a loading device consisting of electrodes immersed in the intake canal and controlled by suitable switches, is provided. The operation is automatic by means of a group of relays and magnetic switches, current transformers, etc., so connected that when the amount of excess regenerated power reaches, say 300 kv.-a., the closing relays throw in one water rheostat on the 11,000-volt bus. As soon as the regenerated power exceeds the capacity of one water rheostat by 300 kv.-a., another closing relay throws the second water rheostat in on the 11,000-volt bus. The difference between the amount of excess regenerated power and the capacity of the water rheostat in service is made up by the generators. When the excess regenerated power has become reduced to zero, with one rheostat in service, all of the rheostatic load being sup-

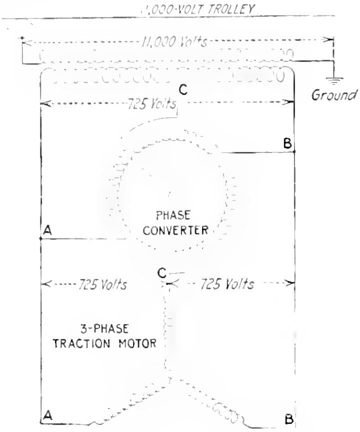


Fig. 9. Phase-Converter Circuit

plied by the generators, one of the tripping relays trips the circuit-breakers and this cuts the rheostat off the 11,000-volt bus. These water rheostats are located outside of the transformer house, as shown in Fig. 5.

Transmission and Substations

As previously mentioned, power is transmitted at 44,000 volts, 25 cycles, single-phase to five substations, where it is stepped down to 11,000 volts. The oil circuit-breakers in the substations are remote-controlled and will be operated from adjacent signal towers or passenger stations or the yardmaster's office, thus requiring no special attendance. The transformers are of the single-phase, oil-insulated, water-cooled type, with primaries wound for 44,000 and secondaries for 11,000 volts, and are equipped with thermostats which, at high temperatures, close a bell-alarm circuit to the nearest operator's office. Two transformer filter outfits have been provided, one for the power house and the other for the substation. Each equipment consists of a filter press, drying oven, and motor-driven centrifugal oil pump.

Locomotive Details

From the 11,000-volt trolley the operating current is taken by a pantagraph and led to the locomotive transformer through an oil circuit-breaker. A phase-converter is connected to the low-tension side of the transformer and operates constantly when the locomotive is in service. To its extended shaft are coupled a blower for cooling the motors, transformer and other parts, and through a clutch, the air compressor. The converter is an induction motor with a short-circuited or cage-wound secondary, having two windings on its stator, one to drive the rotor and the other to furnish current out of phase with the main supply current. The motor circuit of the primary winding of this converter is connected across the secondary of the locomotive transformer and receives current at 725 volts. The arrangement of winding is such that with the converter running, a current of 90-deg. phase displacement is induced in the second winding on the primary of the converter. By connecting this displacement circuit to the middle tap of the main transformer, a three-phase current is produced by the ordinary

PRINCIPAL EQUIPMENT OF NORFOLK & WESTERN RY. ELECTRIFICATION*

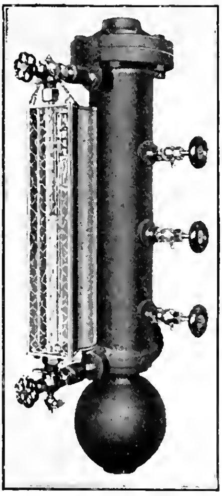
No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
10	Boilers	Stirling	677-hp.	Steam generation	200-lb. gage, 150 deg. superheat	Babcock & Wilcox Co.
10	Stokers	Underfeed		With boilers	Capable of 300 per cent. rating	Westinghouse Machine Co.
1	Stack	Radial-brick	268 ft. high			Alphons Custodis Chimney Construction Co.
	Flues and ducts			Serving boilers		C. B. Nicholson & Co.
3	Forced-draft fans	Multivane	150,000 cu. ft. air per min.	Boiler draft	Turbine-driven; 6-in. water press.; 540 r.p.m.	B. F. Sturtevant Co.
1	Coal-and ash-handling equipment					R. H. Beaumont & Co. and Shephard Crane & Hoist Co.
2	Feed pumps	Horizontal, volute, three-stage		Boiler feed	650 gal. per min. against 600-ft. head, 2750 r.p.m.	Westinghouse Machine Co.
2	Feed pumps	Horizontal, volute, single-stage		Supply to heater	650 gal. per min. against 45-ft. head, 1800 r.p.m.	Westinghouse Machine Co.
1	Heater	Cochrane		Heating feed water	225,000 lb. water per hr. from 40 to 205 deg.	Harrison Safety Boiler Works
3	Turbo-generators	Horizontal, three-phase	10,000-kv.-a.	Main power units	Steam press. 190 lb., 150 deg. superheat, 28½-in. vac., 1500 r.p.m., 11,000 volts, single-phase for traction service, three-phase for auxiliary service.	Westinghouse Machine Co. and Westinghouse Elec. & Mfg. Co.
3	Condensers	LeBlanc		Main turbines	145,000 lb. steam per hr. with cooling water at 70 deg. 28-in. vac.	Westinghouse Machine Co.
1	Cooling-pond equipment	Spray		Condensing water		Spray Engineering Co.
	Steel piping and flanges					M. W. Kellogg Co.
	Pipe fittings	Cast steel				B. F. Shaw Co.
	Valves					Prall & Cady Co.
	Cast-iron pipes					Glamorgan Pipe & Foundry Co.
	Pipe covering			Heat insulation for piping and flues		H. W. Johns-Manville Co.
1	Storage battery		160 amp.-hr.	Control equipment	220 volts	Electric Storage Battery Co.
2	Exciters	Turbine-driven	600-amp.	Excitation for main generators	250 volts, 2200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Exciter	Motor-driven	600-amp.	Excitation for main generators	250 volts, 2200 r.p.m. driven by three-phase motor	Westinghouse Elec. & Mfg. Co.
3	Transformers	Single-phase, oil-insulated water-cooled	5000-kv.a.	In power house; traction load	11,000 to 44,000 volts.	Westinghouse Elec. & Mfg. Co.
	Switching equipment					Westinghouse Elec. & Mfg. Co.
	Power-house wiring					General Electric Co.
1	Air compressor	Steam-driven	112 cu. ft. air per min.	Tools and cleaning	100 lb. pressure	Chicago Pneumatic Tool Co.
1	Crane			Power house		Alfred Box & Co.

*Substation, line and locomotive equipment not listed two-phase and three-phase methods of connection (see Fig. 9). It is necessary only to convert a portion of the current used in the motors, as a large part comes directly from the main transformers. For starting the converter, a single-phase series commutator-type motor is mounted directly on its shaft.

Each locomotive is equipped with eight traction motors of the three-phase induction type with wound secondaries for four-pole and eight-pole operations. There are two running speeds, namely, 14 and 28 miles per hour. In starting, resistance is inserted in the secondary circuit of the motor by means of a liquid rheostat. For the 14-mile speed all the motors are connected in parallel having the eight-pole combination, and for the 28-mile speed they are also connected in parallel, but with the four-pole combination.

Safe Guard Gage Glass Reflector

In the safe operation of a boiler it is of the greatest importance to be able to see the exact water level, and the more clearly the water line can be seen, the better for all concerned. In this connection the Reordway Manufacturing & Sales Co., of Chicago, has recently perfected a gage-glass reflector and guard which makes the water show red and protects the operator against accident by breakage of the water glass. The device surrounds the gage-glass. It is made of aluminum with a wire-glass front. Within the casing an electric light so reflects on the water as to make it appear red, thus making a positive distinction between that part of the glass containing water and the part containing steam. The water level can be seen from any point in front of the guard and the possibility of a false level due to discoloration of the glass or condensation running down the sides is avoided.



Reflector and Safe Guard

At both the top and bottom of the reflector rubber gaskets prevent the metal from touching the water glass, and as the latter is inclosed, it is maintained at a temperature approaching that of the steam. The glass is not subjected to drafts in the boiler room, and the strains due to expansion or construction are obviated to such an extent that breakage is less frequent. Even if breakage should occur, the aluminum casing and the wire-glass cover protect the fireman from any serious injury. The reflector is made to fit any standard water-gage glass and is easily applied.

Railroad Expenditures—The average expenditure of one of the leading Eastern railroad systems every time the clock ticks off a minute, is $191.63 for supplies. In a year it buys $100,722,006 worth of material of such wide diversity as coal and soft soap, ink and feather dusters, steel and paint.

JUST FOR FUN

Getting a High Vacuum

The engineer was summoned to the office upstairs to see what was wrong with the radiator. Though it was a vacuum system, the radiators were full of water, which indicated stoppage in the return line. After examining all valves on the return line back to the boiler room, he went to the vacuum pump. Sure, there was 25 in. of vacuum, and the pump was running free and easy, but the valve on the suction pipe was closed. The fireman stated he could not keep a good vacuum on the gage with the suction valve open, so he closed it and used a little more city water on the spray jet and held up the vacuum beautifully.—*R. A. Cultra, Cambridge, Mass.*

Imported for a Purpose

The inclosed clipping is from a recent issue of an English magazine. The unknown professor mentioned in the advertisement has evidently copied his idea from his American brother faker, but he has put in a few new points which are about as funny as anything I have ever seen in an advertisement. He tells prospective customers that coal ore improves on nature by making the coal give out just as much heat as usual, but that the coal will burn just twice as long as usual.

SCIENCE VERSUS NATURE

Science has demonstrated how it can triumph over nature, for here is a product of mankind which actually improves nature and makes coal give out just as much heat as usual, but uses only half the energy.

COAL-ORE—THE HEART OF THE COAL

It is nothing more nor less than the scientific adaptation of the natural elements of heat storing as discovered by the eminent professor who conducted the experiments. The application of coal-ore has demonstrated infallibly that coal can be made to last twice as long and yet still give out the same heat. A single **shilling packet** will be ample to treat a **Ton of Coal.**

James E. Noble, Toronto, Ont.

Circuit Incomplete by a Foot

It was the custom of the repairmen in the car barn of a street railway to set various traps to shock any new comer. The drinking water was kept in a bucket on a small shelf. A carefully concealed live wire had been run down the back of the post with a free end of sufficient length to be brought around the post and hooked on to the handle of the bucket. One day a new man started to work, and the water-bucket trap was promptly set for him. Water was sprinkled on the floor around the drinking place to make sure that the ground connection would be good. After the new comer had taken several drinks without result (the connections being examined carefully after each drink and pronounced O. K.) and the rest had gone thirsty all the morning, someone inquired as to his "open-circuited condition." The explanation was quite a surprise to everyone, as he stated that he had helped to shock new men in his time and was perfectly well aware that the water bucket was loaded. He explained that the reason he was not affected was, that he was so unfortunate as to have a cork foot in place of one he had lost, and that it was only necessary for him to raise the good foot from the ground when getting a dipper of water. The limp was on the new comer, but the laugh was on the gang.—*J. E. Terman, Hartford, Conn.*

Factors Affecting Commutation

By Arthur H. Brame

SYNOPSIS—The influence upon commutation of armature reaction, induction in the commutated coils, local currents in the short-circuited coils, and the proper selection of brushes.

In the study of commutation it is necessary to consider separately the influence of the distortion of the main magnetic field by the field produced by the armature current, the induction in the commutated coils by the sudden stopping and starting of the currents in the opposite direction, the local currents flowing in them while they are short-circuited by the brushes, and the important part played by the brushes.

Consider first the armature carrying a current supplied from some external source, as in a motor, while the field magnets are left unexcited. Conductors on the same side of the neutral plane carry currents in the same direction, while the conductors on one side carry currents in the opposite direction from those on the other side. The armature as a whole is, therefore, producing a cross magnetization, or a magnetic field across that which is established by the field magnet (see Fig. 1). Since two magnetic fields cannot exist in the same place at the same time, the outcome is a field across the armature which is the resultant of the armature and the field-magnet fields. The armature field at both top and bottom strengthens at one side and weakens at the other the field due to the magnets, and this results in a distortion. When the machine is running fully loaded the coils do not reverse in electromotive force at points directly between the polepieces, but at points further around in the direction of rotation in the case of generators and backward in the case of motors, due to this distortion of the field by the armature currents (see Fig. 2). Therefore, the brushes must be given forward or backward lead, according to whether the machine is a generator or motor; otherwise there will be sparking.

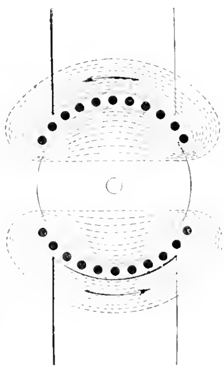


Fig. 1. Illustrating Magnetic Field Produced by Armature

Suppose the armature to be divided into 60 coils connected to a 60-bar commutator. The brushes will short-circuit at least one of these coils, and in some cases two, as they pass from one side to the other. The short-circuit on any coil lasts but a brief time, for if the armature be running at, say 10 revolutions per second, then one coil, forming only $^1/_{60}$ of the whole, will be short-circuited for $^1/_{600}$ of a second twice in each revolution.

Up to the moment of its being short-circuited by the brush, the coil (in a two-brush machine) has been carrying half the total current flowing in the external circuit, and in $^1/_{600}$ of a second this current has to be stopped, the electromotive force in the short-circuited coil reversed, and a current equal to half the external current, but in the reverse direction, started in it. If this be done before the short-circuit is broken the coil will break away from the brush without any sparking, but not otherwise. The only way to accomplish this is to give the brushes a further angle of lead, so that the coil, when on the point of being short-circuited by the brush, is cutting through the field in the reverse direction, so that this particular coil is developing an electromotive force contrary in direction to that which is urging the current through it. The reverse electromotive force on short-circuit rapidly stops the current flowing against it and starts another in the opposite direction. If the current in the short-circuited coil has not reversed on the short-circuit being broken, the current in it will be opposing the currents in the other coils on the side to which it has now been connected, and both will tend to arc across from the receding commutator bar to the brush, as indicated in Fig. 3.

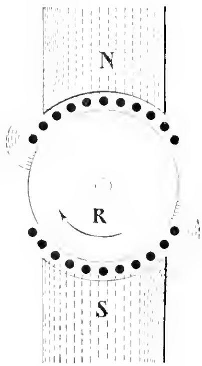


Fig. 2. Showing Field Distortion Due to Armature Reaction

It is evident that if the field magnet be magnetized to a high degree the pole tips will be highly saturated and the distorting effect of the armature current will be considerably less, owing to the high reluctance introduced into the circuit; hence the necessity for adjusting the position of the brushes for changes in the load will be decidedly less. In most modern dynamos this is done to a great extent, and in many machines there is no sparking at the brushes within ordinary variations of load, even on large overloads, though the brushes be fixed in position; this is especially true where carbon brushes are employed and the ampere-turns per commutator bar are small.

The current developed in the armature of a generator has to be collected by brushes pressing on the commutator segments. These are made either of copper or carbon, the brush-holders being designed to suit. Arrangements must be made for feeding the brushes forward as they wear, and to allow any brush to be raised and held off while the machine is running. Carbon brushes offer more resistance than copper, not only in the specific resistance of the substance, but also, and more particularly, in the contact resistance. This extra resistance, although it makes a great difference in the resistance of the circuit formed by the coil which is short-circuited by the brush, does not appreciably affect the resistance of the whole circuit, and it has a very beneficial effect on the commutating properties of the machine. Consider Fig. 4. The current is here flowing out by the carbon brush, and the coil *B*, which is becoming short-circuited by the brush, has a relatively high resistance put into its circuit, soon reducing its current to zero. The current from coil *A* now divides at the brush, the larger portion going directly through the brush and a small portion passing through coil *B* to the brush, for the brush and coil *B* are in parallel. As the coil moves further around, more of the brush comes into contact with segment 3 and less with segment 2, until finally it is only just in contact with segment 2 (Fig. 5).

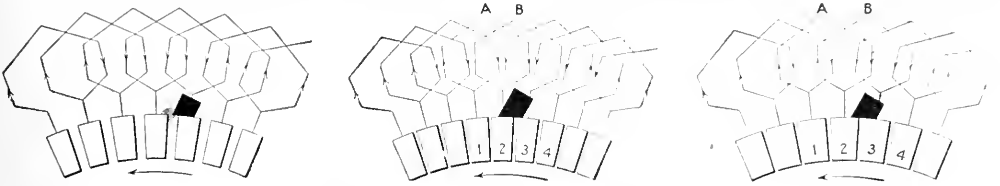


FIG. 3 FIG. 4 FIG. 5

ILLUSTRATING DIRECTIONS OF ARMATURE CURRENTS

As this proceeds the resistance from 2 to 3 across the brush is steadily increasing and, consequently, a larger and larger part of the current in *A* passes through *B* to the brush, until finally, as the brush breaks away from 2, there is little or no current flowing in that segment and, therefore, there is no sparking at the break. This enables the machine to be run with fixed brushes under large variations in the load, often from zero to full load; and the substitution of carbon for copper brushes has often prevented sparking in machines that before gave trouble in this respect.

There is one disadvantage, however, in using carbon brushes—one cannot allow as large a current density in the brush contact, otherwise they would get exceedingly hot. The maximum allowable current density found in practice is 70 amp. per sq.in. against 250 amp. with copper brushes. Since it takes a certain length of time to reverse the current, the brushes must be of sufficient thickness to short-circuit the coils for that length of time; on the other hand, they must not be so wide as to short-circuit a number of coils at the time, as this again would increase the tendency to sparking on account of increased self-induction.

Since the direction of a current causing a certain motion is opposite to the direction of the current caused by that motion, it follows that in a generator the current induced in the short-circuited coil has the opposite direction with relation to the current flowing in the armature from that induced in the short-circuited coil of a motor in the same position, when rotating in the same direction. That is, if in a generator the brushes are shifted so that the current induced in the short-circuited coil has the same direction as that flowing in the half of the armature it is about to join, in a motor revolving in the same direction and having its brushes set in exactly the same position, the current in the commuted coil (which absolutely has the same direction as in the case of the generator) would, relatively, have a direction opposite to that flowing in the half of the armature to which it is transferred by the act of commutation. While the brushes, in order to attain sparkless commutation, must be shifted with the direction of rotation, or must be given lead in a generator; in a motor they have to be shifted backward, or given lag.

In a generator the effect of commutation is a tendency to increase the aggregate magnetomotive force and, therefore, to strengthen the field; in a motor, however, the effect of commutation is to decrease the magnetomotive force and to weaken the field. Iron is very sensitive to slight increases of magnetomotive force, while it is comparatively insensible to a considerable decrease of magnetomotive force. In generators, therefore, the danger of sparking due to improper setting of the brushes is much greater than in motors.

Curve 1, Fig. 6, shows the value of the resistance of a unit section of brush contact plotted against current density in that contact; the resistance decreases as the current density increases, and for higher values than 35 amp. per sq.in. it varies almost inversely as the current density, and the voltage drop across the contact becomes practically constant, as shown in Curve 2. Such curves

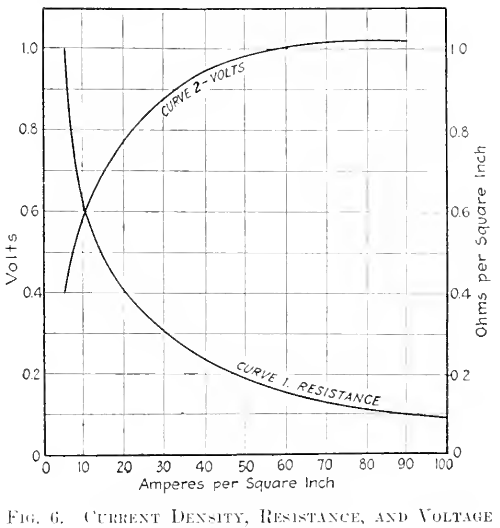


FIG. 6. CURRENT DENSITY, RESISTANCE, AND VOLTAGE DROP OF BRUSHES

of brush resistance are obtained by testing the brushes on a revolving collector ring and allowing sufficient time to elapse between readings to let the conditions become stationary. The resistance from ring to brush is generally greater than that from brush to ring by an amount which varies with the material of the brush.

It would seem that, by neglecting the effect of the variation of contact resistance with current density, the results obtained would be of little practical importance. It is found, however, that the variation in resistance is largely a temperature effect and that at constant temperature the contact resistance does not vary through such extreme limits; also that, due to the thermal conductivity of carbon, the temperature difference between two points on a brush contact is not very great.

Suppose that, having reached the value of 10 amp. per sq.in., and the resistance having become stationary at 0.06 ohm per sq.in. (see Fig. 6), the current density were suddenly increased to 40 amp. per sq.in. The resistance in ohms per square inch would not fall suddenly to 0.023, but would have a value of about 0.06, and this would gradually decrease until, after about 20 min., the resistance would have reached 0.023—the value which it ought to have according to Curve 1, Fig. 6. This explains why a machine will stand considerable overload for a short time without sparking, whereas if the overload be maintained it will begin to spark as the brush temperature increases and the contact resistance decreases.

Sparking is cumulative in its effect because slight sparking raises the temperature of the brush contact, which reduces the contact resistance and causes the contact to become worse.

The brush contact resistance is found to decrease as the brush pressure increases and as the rubbing velocity decreases, but these effects can be neglected in any study of commutation, since the change due to rubbing velocity is small, while the brush pressure is fixed by the service and is made as small as possible. The brush pressure is seldom less than 1.5 lb. per sq.in. of contact surface, because at lower pressures the brushes are liable to chatter, while if the pressure be too great the brushes will cut the commutator if they are hard or will wear down and smear it if they are soft. A brush pressure of 2 lb. per sq.in. is seldom exceeded except for street-car motors, in which the vibration of the machine itself is excessive, and pressures as high as 5 lb. per sq.in. have to be used to prevent undue chattering.

The average energy expended at the brush contact must also be limited, as may be seen from the following table:*

Kinds of Brush	Current Density	Volts across One Contact
Very soft carbon..........	50-70 amp. per sq.in.	0.6-0.4
Soft carbon	40-65 amp. per sq.in.	0.7-0.55
Fairly hard carbon........	30-45 amp. per sq.in.	1.1-0.9
Very hard carbon..........	25-40 amp. per sq.in.	1.5-1.2

The product of amperes per square inch and volts drop across one contact has an average value of 35 watts per sq.in. It must be understood that these figures are for machines which operate without sparking and without shifting of the brushes from no load to 25 per cent. overload by using the proper grade of brush.

From the preceding, then, it is evident that sparkless commutation will be promoted: First, by dividing up the armature into many sections so as to do the reversing of the current in detail; secondly, by making the field magnets relatively powerful, thereby securing between the pole tips a fringe of field of sufficient strength to reverse the currents in the short-circuited coils; thirdly, by so shaping the pole surfaces as to give a fringe of magnetic field of suitable extent; and fourthly, by choosing brushes of proper thickness and keeping their contact surfaces well trimmed.

The Velocity of Steam in Pipes commonly allowed for medium and high pressure is 6000 to 8000 ft. per min., but the tendency of the present is toward much higher velocities (even to double the figures given), especially where considerable initial superheat is given the steam.

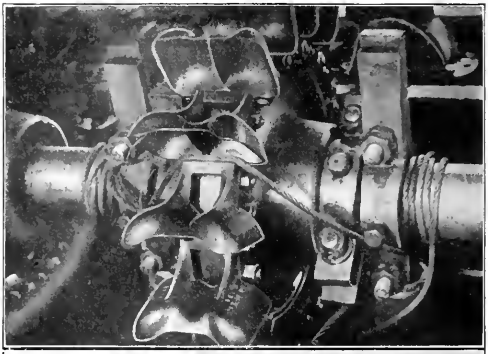
*Arnold, "Die Gleichstrom-machine," Vol. I, p. 351.

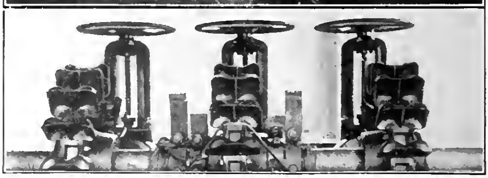
Repair to Waterwheel

By Walter Swaren

From far away Java comes an interesting example of a temporary repair. A waterwheel was shipped from San Francisco into the interior of Java to supply power for a tea plantation. It was necessary to sectionalize this wheel, and provision was made in the usual manner for a light press fit for attaching the hub to the shaft. The equipment for making the necessary press fit being rather difficult to obtain in the interior of Java, some refitting by hand was done. As a result, the fit of the middle spider (there being three spiders on the waterwheel shaft) was too light. After three years' operation it became loosened and worked endways on the shaft until it passed the key, thus rotating freely.

It was necessary that repairs be made quickly, as the accident occurred during the height of the season and





How the Wheel Was Made Fast

not more than two hours could be spared for the shutdown. It was obviously impossible, with the crude tools at hand, to arrange a new keyway or to put in setscrews; therefore, wire cable was drawn across the spider and wrapped tightly about the shaft by means of rough-forged clamps, as shown in the illustrations. It is interesting to note that but little more than two hours was required for making these repairs. The cure proved to be temporary, as in about a week the spider had again worked loose; then it was lashed in place in less than half an hour, which procedure had to be followed several times before the end of the season.

When the season was over, permanent repairs were effected by providing two clamps, one on either side of the wheel, with a notch in each which fitted about the boss on the hubs. These clamps carried bosses which in turn fitted into keyways sunk in the shaft, the whole repair being further held in place by setscrews. This left the spider held by two split-claw clutches.

All of the work was done by native Javanese laborers, under the direction of an engineer trained in the Netherlands.

Air Testing in the Refrigeration Plant

By A. G. Solomon

SYNOPSIS—The writer considers some of the dangers met in testing the refrigeration system with air. These dangers are not altogether absent when testing a new system. A special air pump should be provided always, so that the ammonia machine need not be used as an air compressor. Gage-glasses are not needed on the discharge gas receiver or on oil traps.

Using an ammonia compressor for pumping an air test on a plant is something that should be given considerable attention. It is customary to test the high-pressure side of a plant with 300-lb. air pressure and the evaporating coils and other low-pressure piping with from 100 to 150 lb. Many engineers seem to belittle the danger of using the ammonia machine as an air compressor.

Testing Newly Installed System

First, consider the risks in testing a new plant free from oil and ammonia. The machine is new and has been turned over by hand to ascertain that the clearance is right. Then it is turned over with steam, or with the motor if it happens to be motor-driven. With the steam drive the speed can be as slow as desired, but with the motor drive full speed is quickly reached. During this time the compressor does not draw anything from the evaporating side, as an opening is left so that the air is simply pulled in and forced out. Usually, much oil is put into the compressor to lubricate the valves and piston. Some of this lodges in small pockets in the valve cages and the globe valves in the pipes. After everything is ready the machine is turned into an air compressor and the test is begun. A full stream of water is turned through the water jackets, and often a hose is fastened to the discharge line and water allowed to flow over it to remove some of the heat of compression.

The machine should be stopped and allowed to cool after a discharge temperature of not over 250 deg. F. is reached. A thermometer should be inserted in the discharge line at this time, even if it is not left there for future use. The writer believes it would be a good thing to insist on discharge-temperature readings being taken during the test. The erecting engineer should be instructed as to what is a safe temperature and should keep within that limit. The oil for lubrication of the new compressor should be furnished by the builders, to avoid the danger of using an inferior lubricant or one with a too low flash temperature. This will mean that the thermometers and the oil will be a part of the erecting engineer's equipment. The lubricant used in many refrigerating plants is good as far as the low-temperature test goes, but when it comes to the question of gasifying under high pressure and temperature, that is another story. The danger of gas ignition and the resultant internal explosion is not any greater in the old system than in the new. The result of such explosion may be more serious in the former, owing to the possibility of ammonia being liberated.

Scale May Start Explosion

In one way, the writer thinks, a new system is more liable to explosion than an old one. The cylinder surface and the moving valves and piston are not worn to a smooth finish, and the friction is therefore greater. Minute irregularities in these surfaces may easily create friction which may cause a spark that will ignite the gas given up by the oil used for lubrication. In the old compressor this danger is not present.

Another producer of sparks may be the particles of scale in the pipes. However well the piping is cleaned, there is some scale which becomes loosened and may find its way into the cylinder. A small piece of hard scale, getting between the piston and cylinder wall, may cause a spark. Also small particles of scale and grit are sent through the compressor valves and the pipe work at high speed. These may cause sparks.

Soapy Water as Lubricant Prevents Explosions

There is one positive preventive for such explosions in testing a new plant. Do not use oil for lubrication. Use soap and water or some other material which will not give up a gas when subjected to heat. The amount of moisture thus introduced into the system will do no harm, as nearly all of it will be caught by the oil separator in the discharge line.

The proper way, and a way the writer believes should be insisted on, is the use of a special air pump for testing both new and old systems. Such an apparatus can be made to deliver air at a low temperature, and thus do away with the danger of explosion.

Where it is necessary to use a motor-driven ammonia compressor for pumping the air test, it should be stopped often and allowed to cool. This is annoying and takes a little more time, but it is safe. An hour or two more or less will not make any difference to the plant, whereas the bursting of a cylinder, receiver, valve or pipe work may delay the starting of the plant a week or more.

Glass Gages Not Needed

The proper way to handle the gage-cocks on ammonia gage-glasses needs some little discussion. There are two different ideas as to what is the best position for the cocks to be in—whether they should be left open all the time, or closed and only opened to see how much liquid is in the receiver.

The practice of placing the gage-glasses on the discharge-gas receiver or on oil traps should be discouraged. They are not necessary and are in most cases useless for the purpose intended. On the discharge side of a compression system the gas receiver or oil trap will be cold up to the level of the oil, and by simply placing the hand on it the amount of oil contained is readily ascertained. Glass gages usually become dirty on the inner surface and the oil level cannot be plainly seen.

So this leaves but two places where glasses are needed. The first is on the liquid-ammonia receiver. To successfully operate the plant the liquid level in the receiver must be known at all times. A glass gage is the only positive indicator. These glasses should be protected with a fine-mesh screen to prevent pieces from flying when the glass breaks. They should also be protected in some way from the danger of being hit by something dropping on them or by material being carried past the receiver. The writer knows of one case where the wheel from a valve directly above the receiver came loose and in falling it not only broke the glass, but also one of the cocks was broken off. Ladders and lengths of pipe are often carried around in the engine room, and they may come in contact with the glass. But besides such accidents, glasses often break in a seemingly mysterious manner. In one plant where a glass had been broken by being hit with something and a lot of ammonia lost before the cocks were closed, the chief engineer gave orders to keep the cocks shut except when the operator wished to see the liquid level. Several glasses broke during the following few weeks. This is easily explained. When the cocks were opened and closed, the liquid ammonia at the temperature of the condenser was bottled up. The heat of the engine room caused this liquid to expand and the pressure burst the glass. After a little study this was overcome by leaving the upper gage-cock open enough to keep the pressure from becoming high. Another scheme was tried with success in a plant where glasses had burst several times. If the cocks were left open it invariably happened that something hit the glass; when they were kept closed the pressure burst the glass. Finally, globe valves were placed between the gage-cocks and the receiver, and the core of the cocks was filed so that there was a small opening even when they were closed. The filing had the same effect as a leaky cock. Then the cocks were left closed and the two valves left open. If the glass broke, the amount of ammonia escaping was so small that a man could get to the valves to shut them.

There are on the market several styles of safety gage-cocks that are provided with ball checks and are supposed to shut the ammonia off in case the glass breaks. These can be depended on to a certain extent, but are like most automatic apparatus in that they are liable to fail when needed.

Gage on Brine Cooler

The other place where glass gages are used is on shell-type brine coolers where it is necessary to know the liquid level. These cocks are always left open and the glasses do not give much trouble by breaking. The pressure is seldom over 20 lb., and a man can get to and shut the cocks without much danger. But they should be provided with chains or chords so placed on pulleys that they can be closed from a point at least twenty feet away from the glass.

Electrically Operated Stop Valve

A large railroad company was handicapped by not being able to quickly stop the engine which operated the coal and ash conveyor, because this engine was located in a remote and inaccessible place. When something went wrong with one of the conveyor buckets, such as a section of the conveyor chain jumping the track, which, while not frequent, did occasionally happen, considerable damage was caused, because the engine could not be stopped quickly. Other accidents are likely to happen, such as workmen getting caught in the machinery. In coal breakers accidents caused by men being caught in the machinery are frequent. In most mines it is necessary for someone to ring a bell in order to have the engineer stop the engine.

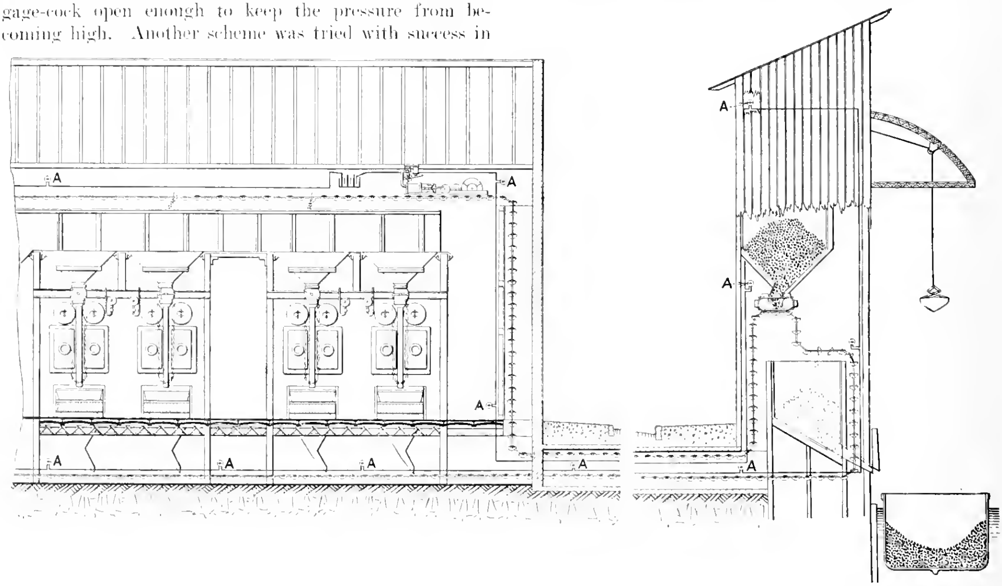


Fig. 1. Conveyor System, Push Buttons and Electrically Operated Valve

With the electrically operated valve herein described, anyone can quickly stop an engine by pushing a hand-push switch, any number of which may be located at intervals along the length of the conveyor path, as at *A*, Fig. 1. This device does not remove the cause of accident, but it does offer a means for preventing accidents such as mentioned from resulting seriously, as the conveyor can be brought to a stop within 6 in. of travel after a switch has been pushed.

Description of Valve

Fig. 2 shows a side and end view of an electrically operated valve of the inverted-lever type. It is fitted with

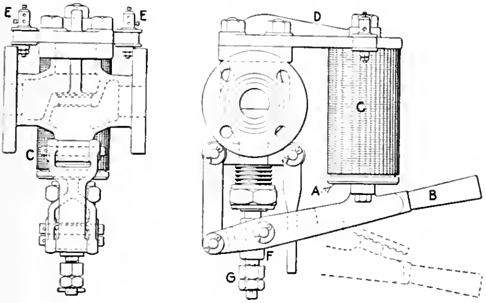


Fig. 2. Front and Side View of the Electrically Operated Valve

a hand lever *B* that carries an armature *A* by means of which the valve is held open by the ironclad closed-circuit magnet *C*, supported from the valve cover *D*. This carries heavy binding posts *E* on either side, which take the magnet and line terminals. The hand lever *B* is suspended from the valve body by a link and carries a trunnion *F* by means of which the valve spindle is held in its highest, or open, position. When the current is interrupted on the coil, a hand-push switch being operated, the hand lever drops to the position shown by the dotted lines, and as there is a clearance between the bottom of the trunion tee and the nut and check nuts *G* on the spindle, the weight of the lever strikes the spindle an impact blow, so as to insure closing against the stuffing-box friction. The pressure enters the valve body on the top seat side and acting on the valve disk, keeps the valve closed. aided by the weight of the disk spindle, and the hand lever resting thereon.

A guide is placed on the side of the body opposite the link, which fits into the crotch of the hand lever and relieves the spindle of any strain which might be caused by pulling the lever sideways. The two lugs on the body—one for the link and the other for the guide—are indentical and permit the hand lever to be turned to face the opposite way.

The cover can also be fitted on so that the magnet will face in an opposite direction, which permits the valve to be made either right- or left-hand to avoid interference with obstructions in restricted places.

The magnet can be wound for a 10-cell storage battery or 110-volt direct current. For 220 volts an outside resistance unit is used in series with the 110-volt winding. The current consumption is approximately $\frac{1}{4}$ ampere for the storage battery and $\frac{1}{10}$ ampere for either 110 or 220 volts, direct-current.

After the valve has been closed by the opening of the circuit on the coil, it is again opened by lifting the hand lever to its highest position, where it will be held by the attraction of the magnet, the circuit having been reëstablished immediately after having been opened, because the hand-push switches are of the self-resetting type.

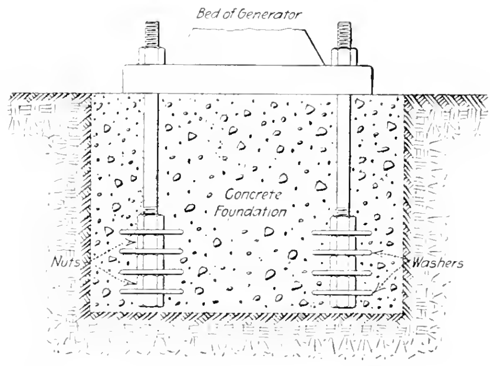
This valve must be used in conjunction with the existing stop or throttle valve on the engine, and should be placed between it and the engine cylinder. The valve is made in sizes from 1 to 2 in., inclusive. It is manufactured by the Schütte & Koerting Co., Thompson and 12th St., Philadelphia, Penn.

Anchoring Foundation Bolts in Concrete

By Terrell Croft

The effectiveness of the adhesion between an iron rod and the concrete in which the rod is embedded does not appear to be generally appreciated by many men who install concrete foundations for machinery. For example, the arrangement shown was used in a certain instance to provide an anchor for the foundation bolts of a machine. The series of nuts and washers on the lower ends of the bolts was entirely unnecessary, as will be demonstrated.

The maximum adhesion between a round iron rod and concrete amounts to between 250 and 400 lb. per sq.in. of contact area. A safe value for this adhesion may be taken as 75 lb. per sq.in. These values have been verified many times by actual tests. Working from these data, it can be shown that if a round iron rod is embedded in concrete to a depth equal to 30 times its diameter the rod will break before it pulls from the cement if force is applied to effect its withdrawal. Therefore, if a 1-in. diameter foundation



Unnecessary Nuts and Washers on Anchor Bolts

bolt with its surface perfectly smooth be set in concrete for a depth of 30 in., the rod will break before it can be pulled loose from the concrete. Roughening the rod by threading it or by chipping or by cutting fins in it has very little effect, one way or the other. However, as a matter of precaution it is always well to use for a foundation bolt a rod threaded and having a nut on the lower end. On this nut a cast-iron building washer or a square piece of wrought-iron plate can rest, which will insure against withdrawal if the bolt is not set 30 or more diameters in the concrete.

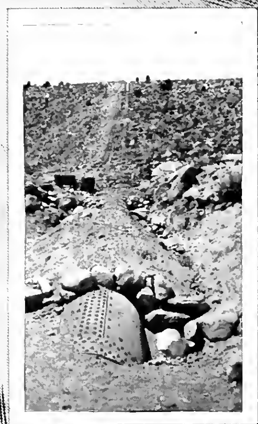
SNAPSHOTS ALONG THE BIG CREEK DEVELOPMENT

No. 1 DAM

HILLSIDE DAM

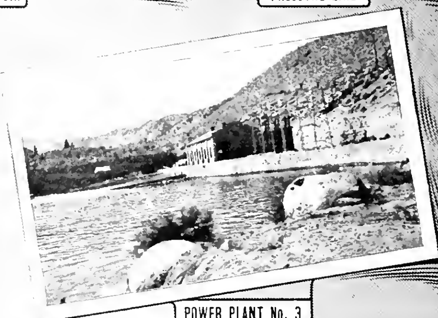
150,000 V. LINE

HILLSIDE RESERVOIR

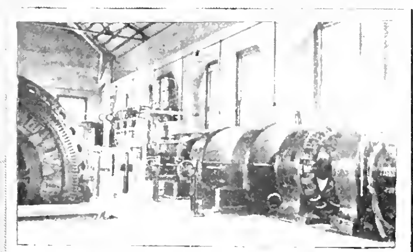


PRESSURE LINE

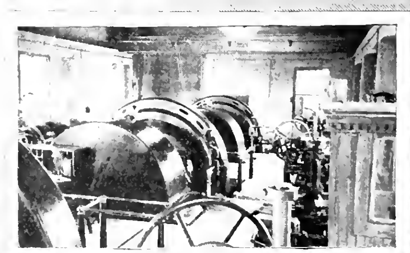
POWER PLANT No. 2



POWER PLANT No. 3



INTERIOR OF No. 2 POWER PLANT



INTERIOR OF No. 3 POWER PLANT

Air-Lift Efficiency

By E. M. Ivens

SYNOPSIS—Probably no mechanical device is as little understood in detail, or is subjected to so much abuse on one hand and praise on the other, as the air lift. Many engineers maintain that the air lift is inefficient, and should never be employed when anything else is obtainable; others credit it with a higher efficiency than is actually attained. Somewhere between the extremes is the proper place for the system.

Two descriptive theories of the air lift have been advanced—one by J. P. Frizell in 1880 and the other by Dr. Julius Pohlé in 1892. Each was granted a patent on a system of piping a well, and in each letters patent the theory is given.

Mr. Frizell says: "My present invention has for its object the elevation of water in a simple and convenient manner by the introduction thereunder of compressed air; and it consists in causing a column of water to ascend in a pipe or conductor by the injection therein, at or near its bottom, of compressed air, the weight of the air and water thus commingled being overcome by the weight of the external water which is thus utilized as a motive power to elevate the water." . . .

Dr. Pohlé says: "The object of the invention is to effect successfully and practically the elevation of the water to a much greater height than has heretofore been deemed economical with compressed air, and to avoid the results due to an ultimate commingling of the air and water, as well as to dispense with all valves, annular spaces and solid pistons. In accordance with my invention, the air is not directed into the water in the form of fine jets or bubbles, which would very readily commingle intimately with the water, but is delivered in mass, and the water and air ascend in well defined alternate layers through the eduction pipe."

Mr. Frizell claims a thorough aëration for his system, while Dr. Pohlé claims a piston-like layer formation of air and water for his. Fig. 1 is an illustration of the two principles.

Dr. Pohlé's idea was that the pistons or layers of air entirely filled the cross-section of the discharge pipe, but as shown in Fig. 1, in actual operation these air pistons only partially fill the cross-sectional area. Consequently, each ascending air piston cannot carry all the water before it; a certain amount (that contained between the air piston on the walls of the eduction pipe) is not raised and the air piston is said to "slip" by this water. This slippage loss is the most serious to be contended with in air-lift practice.

In a mathematical theory developed by Prof. Elmo G. Harris, it is shown that the air-slippage loss varies with the square root of the volume of the air bubble admitted to the water column, therefore it is advantageous to reduce the size of the bubbles by any means possible. This undoubtedly is nearly correct because it is only reasonable to suppose that the sum total of air-slippage losses will be considerably smaller in a rising column of air and water if a large number of finely divided bubbles are introduced than if a comparatively few large ones are employed. In other words, it is evident that, taken as a whole, the cross-sectional area of the pipe is more effectively occupied by the air in the Frizell aëration principle of operation than in the Pohlé piston-like layer principle. Experiment plainly indicates that this conclusion is correct.

Application of the Air

One of the first considerations in designing an air lift for any set of conditions is the manner of introducing the air, or the method of piping the well. Any system

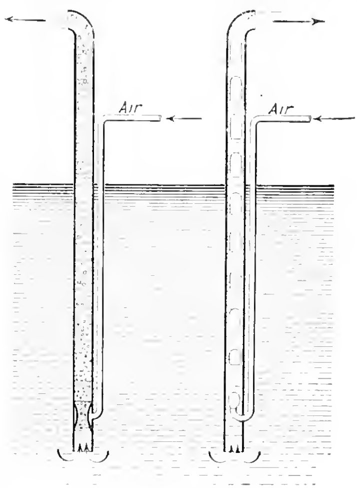


Fig. 1. Aëration Principles of Operation

that finely divides the air volume and provides a free passage for the mixed air and water will be found satisfactory. In Fig. 2 are shown a number of the systems of piping most frequently installed, the letters *A*, *B*, *C* and *D* referring to parts common to each system. Besides these there are several manufactured systems having specially designed head and foot pieces and for which broad claims of superior economy are made. In some of these dependence is put upon refined nozzles and deflector tubes for obtaining the efficiency claimed.

Submergence

Air slippage is also affected by the amount of submergence, or the distance below the surface of the water that the air is admitted to the discharge pipe. To thoroughly appreciate the importance of this feature in air-lift design, consider briefly the characteristics of the bored well and the water-bearing stratum that it penetrates.

Water-bearing strata usually consist of sand or gravel. At some point, which may be more or less remote, these strata reach the earth's surface, where they receive their supply of water from rivers, springs or rainfall. The ideal arrangement is the water-bearing stratum located between two impervious strata, so that there is no escape of water either upward or downward. No such perfect formation exists, but nearly impervious confining strata are found, so for the sake of simplicity of explanation we may assume that the water is held in the stratum in the same manner as in an underground pipe. This stratum we will assume to have a source of supply without an outlet.

Suppose now, that, as illustrated in Fig. 3, a well were drilled at A, piercing the upper strata and entering the water-bearing stratum. An outlet is now provided and the water, seeking its level, will rise up in the well until its surface at B coincides with a horizontal line drawn from the surface C of the source of supply. The distance from the ground surface to the water surface in the well is known as the *static head*.

If an air lift is installed in the well, as shown in Fig. 4, and operation begun with the static head h, there will be created a flow from the source of supply to the mouth of the well. Immediately the initial water level XB drops with a head loss XC due to the friction of the water in passing through the stratum and entering at the lower end of the well. Under the dynamic conditions, the head at the source cannot then maintain an equal head in the well, and the difference between the two is known as the *well head drop*. The *static head* plus the *well head drop* is known as the *pumping head* of the well.

Referring to Fig. 4, the air pressure introduced at A (pounds per square inch) necessary to start operation of the well is equal to the distance h_s in feet multiplied by 0.434, and the pressure necessary to keep the well operating after it has been started is equal to the difference in feet of h_s and the well-head drop multiplied by 0.434; so that the well-head drop in feet may be ascertained by noting the starting and running pressures on the air gage and dividing the difference by 0.434.

Besides the pressure reduction caused by actual falling of the head in the well, there is a slight pressure drop due to established column momentum. In other words, less energy is necessary to keep a column of water moving than is required to start the same column from a state of rest. This pressure difference is plainly equal to the velocity head, which is $\frac{v^2}{2g}$, multiplied by 0.434.

There is a certain amount of frictional resistance in the eduction pipe, and this increases the operating pres-

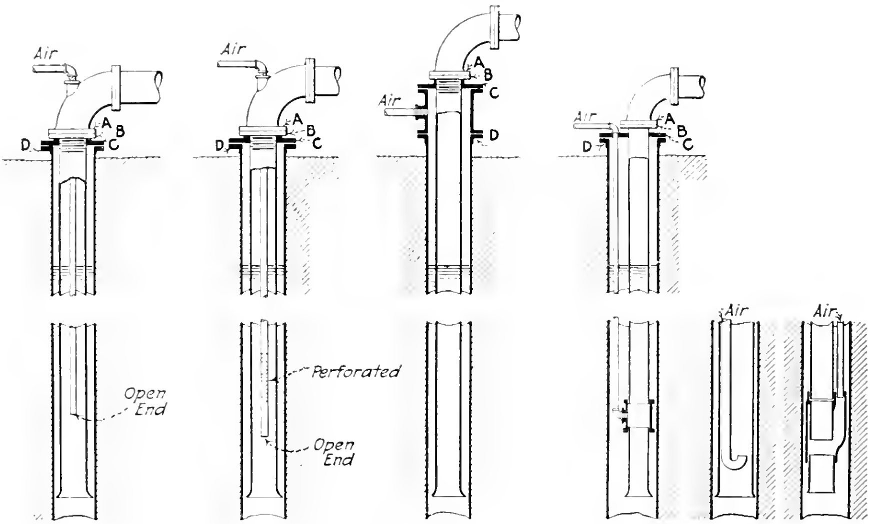


Fig. 2. Piping Systems Most Commonly Employed for Air Lifts

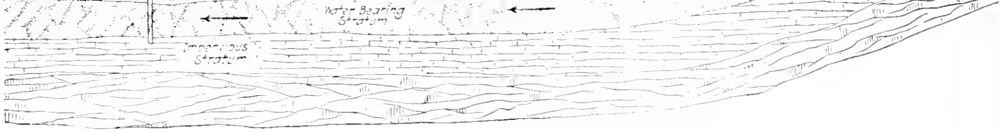


Fig. 3. Static Head of Well Bored to Water-Bearing Stratum

sure over that stated. It is usual to assume that this pressure increase cancels the pressure decrease due to column momentum. For all practical purposes, then, it is sufficiently accurate to say that the submergence in feet is equal to the air pressure multiplied by 2.31 or conversely, of course assuming that the air-transmission losses have been accounted for.

The air pressure that the compressor must operate against is dependent upon the amount of submergence (plus air-transmission losses) of the air line. Experience has shown that as the submergence is increased the air-slippage losses decrease, which means that a lesser volume but increased pressure of air is needed; on the other hand, decreased submergence requires increased air volume but decreased pressure Since these two factors (pressure and displaced volume) constitute work, it is important that the question of submergence be carefully considered.

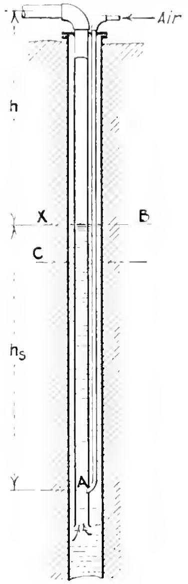


FIG. 4. STATIC HEAD AND WELL-HEAD DROP

There are no rules or laws that tell just what constitutes proper submergence; it is purely a matter to be determined by actual experiment in each case. A number of tests should be made with varying depths of submergence and the most advantageous depth selected. This is a very simple matter, indeed, and well worth the time expended. To show the effect of varying submergence on the efficiency of an air lift, there is reproduced in Fig. 5 a typical submergence curve. The curve was plotted from the results obtained from a test made on a well owned and operated by the City of Hattiesburg, Miss.* As will be noted, the efficiency falls off rapidly between 50 and 65 per cent. and between 75 and 95 per cent. submergence, but between 65 and 75 per cent. the difference in efficiency is only about 1 per cent. The most advantageous point of submergence is 70 per cent.

The proper percentage of submergence varies with the dynamic lift, decreasing as the lift increases. From numerous tests the writer has found the following to be about right, though, as stated, only a test can accurately determine the proper submergence in any particular case.

Lift	Submergence	Lift	Submergence
25 to 50 ft.	70 per cent.	201 to 300 ft.	50 per cent.
51 to 100 ft.	65 per cent.	301 to 400 ft.	45 per cent.
101 to 150 ft.	60 per cent.	401 to 500 ft.	40 per cent.
151 to 200 ft.	55 per cent.		

THE EDUCTION PIPE

Another factor which affects to a large extent the efficiency of operation of an air lift is the size and design of the discharge or eduction pipe. The small area of the well and the standard pipe diameters prohibit nicety of construction, even if enough were known to prepare an accurate design, but a material gain in efficiency can be made by exercising a little care and judgment in the use of our limited facilities and knowledge.

It must be remembered that the discharge pipe transmits a mixture of a practically incompressible liquid and a very elastic gas, and both are under a varying pressure. At the lower end of the pipe the pressure is equivalent to the depth of the submergence, and as the mixture rises the pressure reduces in proportion. The reducing pressure causes the air to expand and occupy an increasing area of the pipe. This causes the velocity of travel of the column to increase as the top is approached.

The demands of high efficiency for transmitting a mixture of air and water are conflicting. Air-slippage losses increase as the velocity of flow is diminished, and water frictional losses increase as the velocity squared is increased. In figuring the pipe diameter it is necessary to ascertain a velocity of flow where the sum of these two losses is least. Here, again, is the need of experience and experiment (for there is no other guide) and, unfortunately, we have neither. Then, too, we have the varying column velocity mentioned to contend with.

About all that can be said is that at no point in the discharge pipe should the column velocity be as low as

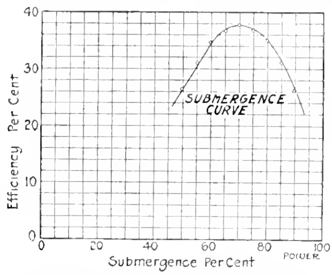


FIG. 5. VARIATION IN EFFICIENCIES FOR DIFFERENT PERCENTAGES OF SUBMERGENCE

that with which an air bubble will ascend in still water, and on the other hand at no point should it be so high that the water-friction losses overcome any gain obtained by small air-slippage losses. Also, the column velocity should increase as the air volume expands.

The writer has obtained good results with an initial velocity of 8 to 11 ft. per sec. and a discharge velocity of 22 to 24 ft. per sec. In high lifts and consequently long discharge lines, to prevent the velocity becoming excessive a gradually increasing pipe should be used. Initial and final velocities in each section of pipe of approximately 11 ft. and 22 ft. respectively will be found very satisfactory.

AIR PIPE

In a large percentage of air lifts the pipes for transmitting the air are too small. For obvious reasons these should be as large as possible, within reason. A velocity of travel of 30 ft. per sec. is considered good practice.

EFFICIENCY

If due consideration is given to the prevention of air-slippage losses and other economy essentials observed, the actual pumping efficiency of the air lift compares favorably with that of any other system of deep-well pumping.

*See page 116, "Pumping by Compressed Air," by E. M. Ivens.

When reliability and convenience are considered the air lift stands alone, and where conditions are suited it should be installed, by all means.

The very simplicity and reliability of the air lift have, however, gotten it into trouble a number of times. It has been installed where sufficient submergence was not available, and, consequently, the efficiency proved low. The one and only drawback to the air lift is the high percentage of submergence necessary to efficient operation.

The writer has obtained pumping efficiencies varying from 50 per cent. on lifts of 50 to 75 ft. to 18 per cent. on lifts of 900 to 1000 ft. These efficiencies were obtained, of course, after experimenting to ascertain the proper submergence.

Steam Generation in a Wood-Distilling Plant

By Lawrence Eddy

A battery of steam boilers burning six different substances—gas, liquids and solids—in the same fireboxes is rather unusual. Yet such are the conditions in the plant herein described, and which are quite typical of the wood distilleries in the East.

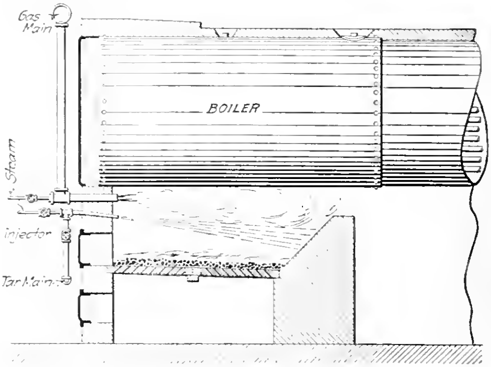
The steam for this plant is generated in three return-tubular boilers rated at 150 hp. each. They are set over stationary grates whose dimensions are approximately 6x6 ft. Air is supplied by a strong natural draft.

In the process of distilling hard woods several unmarketable products are obtained which are also combustible. They are burned, in this case under the boilers, as much for the sake of being rid of them as for the heat energy which they possess. When the wood is heated in the ovens about 20 per cent. of it, by weight, is converted into a noncondensible gas. In this plant, which burns 60 cords a day, this will amount to about 600,000 cu.ft. every 24 hrs. After washing, the gas is led in cast-iron mains to the upper corner of each firebox, as shown in the sketch. It merely escapes from the end of the pipe and mixes with the furnace gases, burning with a pale-blue flame in the top of the firebox. Its combustion is supported by the excess air which passes up through the fuel bed on the grates. A steam jet placed in the pipes just before they enter the fireboxes assists the flow of gas and prevents the furnace gases from working back into the mains and causing an explosion when the wood gas is not running. As there is no gas tank in the line, the supply at the boilers is intermittent and must be burned just as it comes, without any regulating valves which might cause a back pressure on the ovens.

The second class of fuels is the wood oils. These distill over with the alchohol and acetic acid, in the processes of purifying the wood vinegar or "raw liquor." They separate from the alcohol and acid by gravity, are washed, and run off to the tar sump where they mix with or float on the tar. They still contain a considerable amount of water and acid.

The residual tars which remain after the alcohol and acid have been distilled off resemble in appearance the familiar gashouse tar and have a very acrid odor, due to acid which cannot be entirely separated from them. Between 1000 and 2000 gal. accumulates every day, and is run off while still hot to the tar sump, together with the oils previously mentioned. Brass piping (to resist the acids) carries the mixture to the fireboxes, into which it is injected with considerable force by a steam jet, as shown. No attempt is made to atomize the liquid, it being merely hurled in large globules against the bridge-wall, spattering back and burning on top of the fuel bed. If fed too fast it builds up into a large mass which has often nearly filled the firebox. It will also run down into the fuel if fed too fast, and make a hard clinker in the grates.

In connection with the plant there is a sawmill which delivers the sawdust and refuse from 7000 ft. of lumber



Connections at Furnace Burning Solid, Liquid and Gaseous Fuels Simultaneously

a day to the boiler room. It is dumped into a bin by a chain conveyor and shoveled by hand into the fireboxes. When too green and wet to burn readily the sawdust is sometimes mixed with coal before firing. It is the practice to fire the sawdust all into one firebox; this is, of course, wrong, for since it is a much inferior fuel to the coal and the grate areas are the same, it follows that the two boilers fired by coal are overloaded, while the one fired with sawdust does not carry its share of the load.

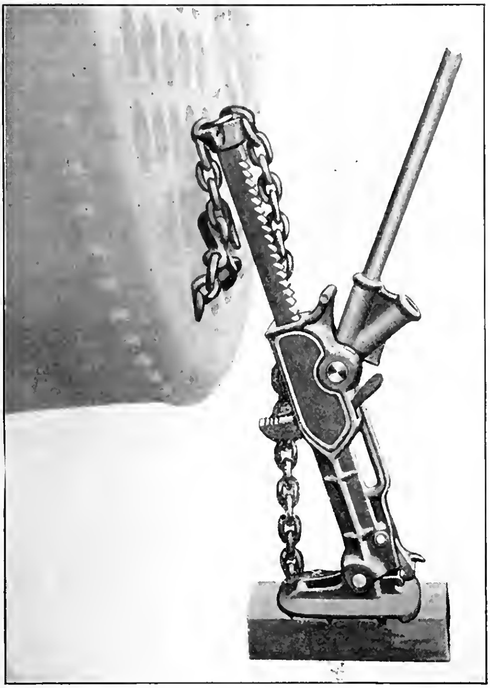
As the waste fuels do not furnish the necessary heat for all steam making, it is necessary to burn large quantities of fine pea anthracite coal on the grates. These fires must be raked off the grates periodically, and in kindling the new fire quantities of charcoal screenings are used. These screenings are a more or less waste product, and make excellent kindling. It is necessary to shut down the dampers when they are on the grates, to prevent them from blowing up the flue, they are so light.

The careful engineer will doubtless see much room for improvement in the arrangements mentioned, but owing to the extremely conservative spirit in the industry it is difficult to try out innovations; the coal bill is regarded as a necessary evil and, apparently, no further thought given to it.

Simplex Emergency Jack

The Simplex emergency jack, recently placed upon the market, is a tool of usefulness and utility wherever there are loads to be lifted or pushed. It practically combines a crane and a jack. The accompanying illustration shows the jack acting as a crane in changing the location of a boiler, wherein pushing at an angle and lifting are necessary.

The standard is a heavy malleable-iron casting ribbed for stress in every direction. The circular bottom of the frame rests with a machine fit upon two circular shoulders, which are a part of the large, well-proportioned base. In this way the base takes the load, and the steel pin acts to hold the frame in position. The rack bar and cap are heavy drop-forgings. The top of the cap is recessed for the chain, which is a part of the equipment. The double socket of crucible steel makes it possible to



SIMPLEX EMERGENCY JACK

handle a load with the jack at any angle. A heavy trunnion bearing supports the socket. The working angle of the jack is from 30 to 90 deg. to the horizontal. The trip at the back of the base either holds the frame in a rigid vertical position or releases it to pivot on the base. Five feet of chain and a 5-ft. steel lever bar comprise the equipment. The jack is manufactured by Templeton, Kenly & Co., Ltd., Chicago, Ill.

A Home-Made Cooling Tower

By A. D. WILLIAMS

An expense often overlooked in the operation of a gas engine is the cost of cooling water. This is particularly the case in city installations where the local water-supply is the only one available and meter rates must be paid. J. F. Kalb, chief engineer at the factory of the Willard Storage Battery Co., Cleveland, Ohio, was confronted with a problem of this kind several years ago. As the size of the power plant was increased by the addition of new engines the water bill increased until it was about $2300 per year, a part of the water being used in the factory, but the larger portion in the engine jackets. Mr. Kalb suggested that a cooling tower upon the roof of the engine room would enable him to use the water over and over again instead of wasting it to the sewer, and finally, he was authorized to build the cooling tower shown in Fig. 1, which was made entirely in the company's factory.

The base of the tower is a lead-lined sump or tank about 5x16 ft., supported on a rack upon the roof and deep

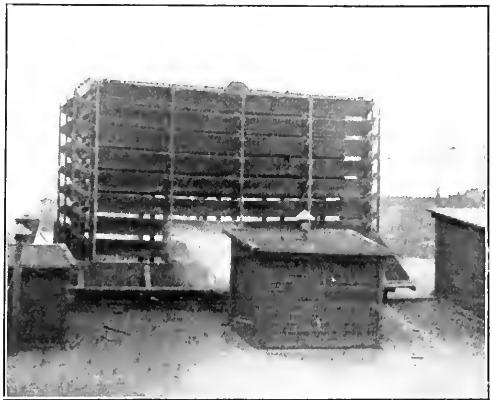


FIG. 1. GENERAL VIEW OF TOWER

enough to hold a foot of water. This tank is provided with an overflow to limit its water line and a ball-and-float valve to admit make-up water as required. The use of sheet lead avoided the necessity for making water-tight joints in the woodwork which might have been more troublesome. The bottom of the tank was built as a

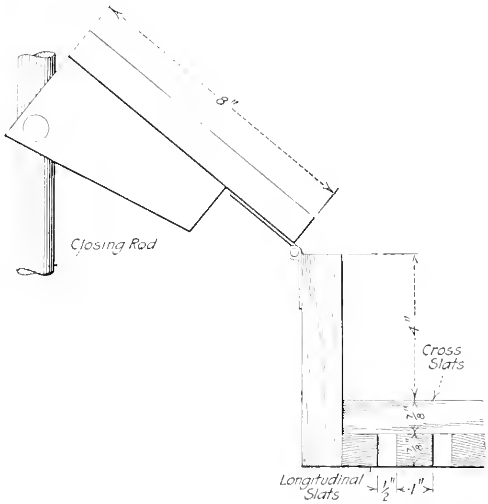


FIG. 2. DETAILS OF TOWER

platform, with heavy battens on its under side, and the sides rest on the platform and are supported by brackets. The joints in the lead lining are burnt, not soldered, and pipe connections are made to the lining by brass flanges soldered to it.

Above the sump there are nine trays about a foot apart, supported by posts that rest on the bottom of the tank.

the lowest tray being 8 in. above the sump. These trays are 4 in. deep and slightly smaller than the tank, their bottoms consisting of racks made up of 1-in. slats crossing at right angles and so arranged that the openings in one tray are not below the openings in the tray above. Water is delivered through a manifold and pipes to the top tray and to the fifth tray from the bottom, the latter arrangement being for use in cold weather. As originally planned, wind-shields were hinged to the top of each tray so that the windward side of the tower could be closed to prevent the spray being blown out on the roof. In practice, however, it was found that these shields became coated with ice and could not be closed in cold weather, except with difficulty. The construction of the trays is shown in Fig. 2.

The cost of this cooling tower, including erection, was slightly under $500, and the first year's operation showed a water bill of $300—a reduction of $2000 from that of the year before. This reduction in the bill caused the water department to test the meter used, after which the accuracy of the bill was not disputed.

Supporting Horizontal Return-Tubular Boilers

By F. W. Dean

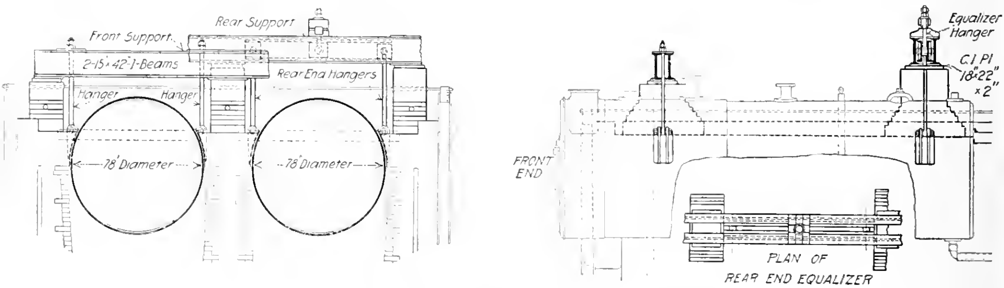
The manner of supporting horizontal return-tubular boilers is of considerable importance. Such boilers should be supported at no more than four points—on both sides near each end. If a boiler is of much length some builders support it at six points. Having an intuition that it is doubtful if the different supports will carry equal weights, they sometimes place springs under the middle ones, thus making the supports somewhat flexible without removing the uncertainty. This is only a makeshift, as even with the use of springs the inequality of supporting pressures is as great as ever.

It is a principle in mechanics that if a body rests on three points the pressure at each point can be determined, and will not change. A three-legged stool always rests properly on its legs and with unchanging pressure, even when it rests on an irregular floor; but a stool with more than three legs rarely presses equally on each, and if its feet were carefully fitted to bear equally on an ordinary floor, a little change in position would destroy the fitting. This illustrates that in supporting a horizontal return-tubular boiler the three-point principle should be applied. This, I believe, was first done by Orosco C. Woolson, and by him made public in a paper read before the American Society of Mechanical Engineers in 1898 and published in Power in November of the same year. If one end of the boiler is supported by two of the usual brackets, one on each side, or is suspended from above by two rods, one each side, and the other end is supported by two rods from above, one on each side, and connected to a hinged equalizing lever, the three-point principle is realized. When this is done the pressure on the brickwork and the strains in the supporting parts never change, even if the brickwork settles. If, instead of having an equalizing lever, the rear head were connected to an overhead beam by means of a hinged joint, the same principle would be applied. This may be a simple and good way to carry out the principle.

If it is doubted that a boiler can stand the strain of being supported at the ends, by treating it as a girder and knowing its weight when full of water, it will be found that the strain in the shell is next to nothing, and it will be seen that this method of support is safe for almost any horizontal boiler which is otherwise properly designed. In practice the case is not as bad as that just suggested, for the points of support are never at the extreme ends, and they can be so chosen that the boiler becomes a well proportioned continuous girder over the points of support, thus reducing the shell strains to a minimum.

Another feature of the usual method of supporting the type of boiler under consideration that merits criticism, is the design of the brackets. While I never knew of the brackets breaking or pulling away from the boilers, they should be designed with a row of rivets below the horizontal part that rests on the brickwork, thus reducing the stress on the bracket rivets.

The illustration shows how I have carried out the Woolson three-point principle since 1899. I first used it for 90-in. boilers for S. D. Warren & Co., but the illustration is that of some 78-in. boilers for Walter Baker & Co., Ltd., at their Montreal plant.



Rear Ends of Boilers Suspended from Equalizers

The Holding Power of Tubes, as shown by a series of tests, is given by J. M. Allen as follows: Tubes expanded but not flared or beaded, 5000 to 7500 lb. pull; tubes expanded and ends flared, 19,000 to 25,000 lb. pull.

Pipe Corrosion—In an effort to settle the important and mooted question as to which material better resists the action of corrosion, the National Tube Co. for years has made a practice of shipping with steel pipe wrought-iron couplings, so that the corrosion of each material could be judged by comparison under the same conditions of service. As a result they have concluded that there is no doubt as to the advantage of steel pipe and have abandoned the manufacture of charcoal and puddled iron for welded tubes.

Editorials

Weak Spots in Hydro-Electric Plant Design

Recent studies of water-power development for electric transmission disclose the need of broader operating knowledge in some instances, in order to realize the highest possible plant efficiency and the safest running conditions. Foresight in development cuts a greater figure in hydro-electric plants than almost anywhere else, in view of the costliness of changing such installations once they are completed. Both on the mechanical and the electrical sides improvements are desirable, as the following typical points illustrate.

Consider the problem of utilizing the available head. In this connection plant location is of decided importance, requiring thorough study by engineers of experience in order to avoid sacrificing a portion of the water drop which can be utilized easily without undue increase in investment. In one plant with a thirty-two-foot head, the available fall on the turbine runners might have been increased to forty feet had the station been located a couple of hundred yards down stream, and the output could have been increased accordingly, with still less service required of the auxiliary steam plant. The operating engineer in charge of the station pointed this out to a visitor familar with such work, and it was seen that the contention was true. The case was one where the company might have saved many thousands of dollars a year had its preliminary plans been shown to the operating staff for criticism. The adoption of the engineer's suggestions was in no sense obligatory, and there could have been no cause for dissatisfaction had the management decided, in the face of all the information before it, to proceed along the lines which it actually followed. Failure to realize the full possibilities of such a situation, however, is a misfortune, for day and night there is a loss of head below the tailrace in this station which might well have been turned into the wheels and made to earn revenue for the company.

Men who have to run plants of this kind realize the value of adequate hydraulic arrangement, including provision for getting at the rear bearings of turbine sets and ample sluice gates at the dam and forebay, so that the requirements of drainage can be met properly. Now and then only partial provision is made for emptying the forebay or for the removal of trash and leaves from the screens at the intakes. Ample lighting facilities here are as important as in the generator room itself. In one recently completed station a space of six feet wide has been set aside for reaching the rear bearings of the water-wheel units; and this, illuminated by a special circuit of tungsten lamps, means real comfort and resulting efficiency for the staff. It costs something in additional masonry or concrete to provide such a space, but in case of trouble, accessibility of such bearings is a valuable feature.

On the electrical side two points that deserve more attention may be emphasized. One is the practice of crowding too much switching and auxiliary apparatus into a limited space on a switchboard gallery, and the other is the need of better mechanical structures to support outgoing transmission and feeder lines. In one instance where the station design was studied in the light of operating experience, the potential transformers for various instruments were mounted on a frame above a concrete bus structure containing oil switches. The designer of the station probably never gave a thought to the danger of replacing fuses on these transformers in such a location, close to busses carrying high-tension energy and reached only by planking carried on pipe framing above the switch compartments. The fuses may be replaced with tongs, but nevertheless the position from which the operator must work is perilous, and had the designer consulted with men experienced in actually handling the type of plant in mind, it is probable that an entirely different location for the transformers would have been found.

Engineers and Supply Houses

One of the engineer's worst "good friends" is the supply house which takes back the articles he claims defective and replaces them without investigating whether the article was originally defective or ruined by misuse. This method of handling claims encourages an engineer to become more careless in his work and works a hardship on all concerned.

The supply houses, and their representatives, are great factors in educating the engineer, but if lax and careless in their business transactions he will gradually become the same in his work. For example, in place of catching the hexagon on the bonnet of a brass valve in the vise, then screwing a piece of pipe into the valve and using it as a lever to loosen the bonnet, he will catch the body of the valve in the vise and try to loosen the bonnet with a monkey- or perhaps a pipe wrench. Then, when the body slips in the vise he will tighten it up and squeeze the seat out of shape, and the valve will leak. This may be either ignorance or carelessness, but it makes no difference, he says the valve is defective and returns it. In order not to lose the business the supply man replaces the valve without a word and junks the ruined one.

How much better for all concerned it would be to take the valve back to the engineer, show him how it had been ruined and how to take it apart, and make him pay for it, as he should. Nearly all manufacturers test their valves before leaving the factory, consequently they have a right to look with suspicion on complaints regarding leakage through the seat.

Some time ago an engineer claimed that three automatic stop and check valves were leaking and didn't open as they should when cutting in a new boiler. They were taken apart and found to be covered with mud, which caused all the trouble. The engineer should have taken these valves apart himself before making complaint.

In another case, where a gate valve was placed in the header between two engines, the first time it was closed it "leaked like a sieve," and complaint was made. Another tested valve was sent, and this likewise leaked. An experienced man was sent, and he found that the expansion in the pipe line was springing the body of the valve. The piping was rearranged and the trouble disappeared. In a new pipe line there is always a lot of pipe scale cuttings, etc., that may lodge in the valve the first time the steam is turned on.

Returning material to obtain new when you are not justly entitled to it is dishonest. You might just as well break into a place of business after nightfall and take what you want. Besides, we pay the bill in the long run.

Definite Engineering Education

Attendance at commencement exercises this month brings many rewards to those fortunate enough to hear the distinguished speakers from far and near, but there is one striking consolation for the man who must stick to his daily task while others loll about the campus and drink in good advice in the auditorium. That is the eternal value of scientific principles, both pure and applied, as a mental resource and stimulus to the individual. Thousands of words have been spoken this month upon the subject of technical education and its relation to modern industry. Much of this has been interesting to hear, but a large part of it has been self-evident, with remarks of scarcely more than a commonplace value to the engineer, be he graduated from the school of experience or from the university of books and laboratories.

We have no quarrel with present methods of engineering education, but we do wish to emphasize the surpassing value of concrete studies in contrast to the ocean of generalities poured forth by many commencement speakers at this season. Some of these men rose to the occasion and drew appropriate lessons for the engineering profession from these epoch-making days in the world's history. Others—well the feeling of many a man after sitting through some of these exercises is one of thankfulness for the solid interest and profitableness of definite engineering principles and problems as a field for putting forth one's best powers of thought and expression. Those of us in, or closely allied with, engineering work can rejoice that we do not have to spend three-quarters or more of our waking hours groping about in the fogs of speculative theory which beset the footsteps of so many "educators." How much more interesting it is to stop leaks in the plant, to figure out a method of utilizing more heat units between the turbine-discharge outlet and the feed pump, to rectify a poor valve setting on the basis of a skillful indicator diagnosis—yes, to master the situation in dealing with that oil salesman, or to make the boss's jaw set with satisfaction in showing him an exceptionally good report of station performance!

A man may have gone back to his Alma Mater this year to celebrate some notable anniversary in his life, and yet he may have come away and gone straight to his job again with greater enthusiasm than ever for the principles on which his work is based and greater interest in its puzzling difficulties. He may have been given inspiration for taking up regular work again by speakers of international fame, or he may have been driven back into his own thoughts by the skill with which titled and "degreed" orators enunciated the perfectly obvious. However it may be, there is not the shadow of a doubt that one of the greatest blessings about working in the engineering field, with all that it implies in self and coöperative education, is the necessity of definite aims, of striving toward some concrete attainment. The lasting opportunities before the engineer for the mastery of specific principles and problems put the hypotheses and assumptions of people less accustomed to deal with realities far into the background as objects of tangible achievement.

Practical College Work

It is always gratifying to see a college or university with a decidedly practical trend. More and more is this becoming the spirit of the modern educational institutions, as contrasted with the learned, but not always useful, reputations which they once held.

The Oregon Agricultural College is making a first attempt to carry its engineering instruction out to the people of the state. During the past three months lectures and demonstrations have been given to the Portland branch of the International Union of Steam Engineers, with an average attendance by the members of over one hundred and fifty. In addition to the lectures, demonstrations have been carried on at various plants in the city, and a number of experiments and exercises have been conducted by individuals interested. One typical instance resulting from this instruction was a saving of eight per cent. in the cost of fuel in one of the largest plants in Portland.

The subjects taken up this year were "Combustion Control" in connection with the operation of heating plants, and "Refrigeration." This work was given by Prof. F. H. Rosencrants. There was also one lecture in "Electrical Engineering," by L. F. Wooster. The work proved so successful that it will probably be carried forward on a larger scale next year, according to a report of Prof. R. D. Hetzel, the Director of Extension.

While we do not wish to see the spirit of the age too commercial, real efficiency as measured in dollars and cents is, after all, the one for which it pays to strive, and if the colleges can teach us how to cut down the fuel expense in our steam plants eight per cent., it behooves us to give them an audience.

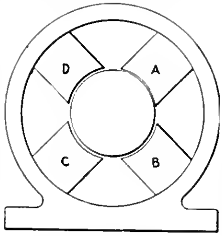
Of course, it does not follow that the savings will be general or that they are always possible. There are many engineers and steam-plant operators who could teach most college professors a great deal about economical combustion. At the same time, the college professors may have come from the ranks and, through the school of experience, know something about firing themselves.

There is a letter by one of our esteemed contributors on page 852 of this issue that nearly all should read—assistants as well as chiefs. It is about wage increases. Assistants should read it because it will reveal to many what the chief is "up against" when he tries to increase the wages of his subordinates. Chiefs should read it to either remind them of, or acquaint them with, the things they should consider before attempting to add to the payroll burden. Employers realize more and more that good wages attract high-quality labor, and most of them will increase wages when convinced it is deserved. But none will make weekly or monthly donations.

Correspondence

Hot Generator Bearing

On starting up a small belted generator that had not been in use for some time the bearing on the commutator end ran hot. The operator, thinking the bearing might be pinching, put liners between it and the cap. Then the bearing got hot quicker than before. When the cap nuts were loosened slightly with the machine running, the shaft was seen to rise out of the bottom bearing and follow up the cap; and the bearing got hot very quickly. This indicated that there was an unbalanced magnetic pull on the armature.



Showing Unequal Air Gap

An examination showed polepiece *A* to have a smaller air gap than *B*, *C* and *D*, which were all alike. There were a few shims back of the polepieces and by removing those back of *A* the air gap under *A* was equalized with those under *B*, *C* and *D*. The cap was then put back on the bearing without any liners and pulled down tightly, and the bearing did not go above a moderate operating temperature.

D. N. McClinton.

Pittsburgh, Penn.

Child-Labor Laws

In a recent issue of one of my engineering magazines I noticed under the heading of "Court Decisions," the following statement concerning child labor in Alabama:

> Under a law enacted at the present session of the Alabama legislature and approved by the Governor Feb. 24, 1915, it becomes unlawful to employ any person under 16 years of age in operating or assisting in the operation of any steam boiler or dangerous machinery.

This evidently is a first step (and a rather weak one) in the right direction, for which the engineers in that state should be thankful, but if the law has only reached that stage where children are prohibited from acting in the capacity of engineers, then the engineers of that state have a long, hard road to travel before they can expect to get a safe and sane license and boiler-inspection law and the recognition which is due their position.

It is my opinion, and I believe that there are many others who will agree with me, that children of 16 years should be in school. Certainly, the work and responsibility of operating a steam boiler and engine should not be intrusted to a child.

In Alabama there are comparatively few boilers as compared with Massachusetts and other manufacturing states, and probably for that reason sufficient pressure has not been brought to bear to put through a reasonably safe law in regard to the operation of power-plant machinery. When we consider that Massachusetts, with its present rigid laws in regard to the construction, inspection and operation of boilers and examining and licensing those who are to have charge of them, is not satisfied with its present laws, and is trying to enact more adequate and in some instances more rigid ones; that Ohio, which now has rigid boiler-inspection and engineers' license laws is about to adopt the new regulations as proposed by the A. S. M. E.; that Wisconsin has already adopted these laws, and some other states and municipalities are contemplating the same step—it does seem that the present situation in Alabama is many years behind that of the other states.

These facts bring out the question, Are the boilers in Massachusetts, Ohio or Wisconsin more dangerous or the men as a rule less proficient than those of Alabama and some other states where there are no inspection and license laws? It is probable that the reverse is the case. Is there any right-thinking employer in any of the states which have any semblance of inspection and license laws (no matter how opposed he may be to the present laws of his state) who will admit for a moment that a boy of 16 or 17 years of age is a competent person to have charge of his engines and boilers? I think not. He may be satisfied to have these lax laws by means of which some other employer may hire the boy, and thus make it possible for him to get a man at boy's wages.

Then there is another phase of the subject which appeals to most employers, aside from the safety of the plant, and that is efficiency. It is well known that it often lies within the power of the engineer to regulate the cost of producing power. For this reason the progressive employer insists on having a man of mature knowledge, judgment and experience in the power plant, to say nothing of a 16-year-old boy who cannot possibly have acquired these qualifications.

It seems to be the aim of some of the employers in some of the states where the laws in this respect are rather lax or where there are none at all, to vigorously oppose legislative bills that come up in regard to boiler-inspection and license laws on the grounds that they are unnecessary and will cost them more money through the engineer's being able to control the supply of engineers to some extent, and of the necessity in some cases of getting other men. They can only see the almighty dollar that they may have to pay for the services of a competent man, to one who has to prove to an exacting board of examiners that he is competent to safely and efficiently operate this class of machinery before he is allowed to have charge of it. But they lose sight of the double eagles that will come to them through the more efficient operation of the plant by the man who can prove that he has the skill to do it.

As time goes on, the laws that govern the requirements of engineers become more exacting, and the employer, realizing the importance of the engineer's position, demands more efficiency in this department, and only those men who are persistent in their efforts to improve their conditions and who are willing to work conscientiously for their employer's interests, will succeed in holding the best positions in the engineering field

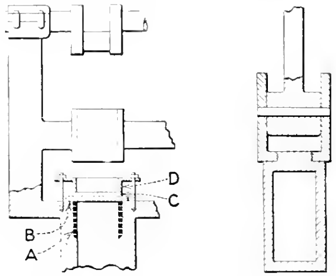
J. C. HAWKINS.

Hyattsville, Md.

Running a Crippled Pump

The threads on one plunger of a geared triplex pump gave way at the point where it screwed into the crosshead.

In order to keep the machine running, the disabled plunger, crosshead and connecting-rod were removed and the cylinder closed, as shown. In the illustration *A* is the



PLUNGER REMOVED AND OPENING CAPPED

plunger packing, which was not removed. *B* is a rubber gasket covering the opening in the end of the cylinder. *C* is a piece of sheet metal under the gland *D* to reinforce *B*. When these parts were assembled and tightened down, the pump was kept running with the two good ones until a new plunger could be made to replace the disabled one.

The construction of the plunger and crosshead is shown, in which the plunger screws into the crosshead which is cylindrical and runs in a bored guide.

EARL PAGETT.

Coffeyville, Kan.

Increasing the Mens' Wages

It sometimes falls to the lot of the chief engineer to approach his superior relative to an increase of pay, not for himself, but for the men of the plant. The task is not an easy one at best. Many a plant owner or manager who is personally a good boss to work for finds it necessary to put such requests "on file." Unless an engineer can show his superior why it will be good policy to increase the existing wage outlay, he will do well to refrain from asking for it.

Hard-headed business men do not increase wages without good reason. The engineer must never forget that to the man of affairs the power plant is usually incidental, and it is a mistake not to appreciate proportion when seeking to add to the payroll. The faithful work of an engineer through many years makes the presentation of recommendations a fairly easy matter so far as the continuance of friendly regard goes. "Bill says the firemen ought to have 15 cents a day more," says a manager of this kind, "and I guess he's right. He has been cutting the unit fuel cost 10 per cent. in the past six months. He tells me the peak is broadening and that we now have to run No. 6 and No. 7 boilers through the noon hour, when the boys used to ease off a bit more than they can today. Anyhow, it's Bill's job to know his men, and so long as the kilowatt-hour expense goes down, I'll back him in sharing the profits with the men."

This is not the kind of manager with which some engineers have to deal, as is shown by the following questions asked in a recent case where the chief thought his men ought to have a further advance in pay because of their faithful work, their punctuality, willingness to see the boss through any troubles and increasing familiarity with the service requirements.

"The work has not changed or increased since the last raise, has it? The men have had frequent raises in pay in the last decade, haven't they? Do you recall any class of men in your station that did not share in the previous increases? The hours have been reduced, have they not? Can you point to any specific increase in the men's efficiency since the last raise? Does the mere fact that your firemen understand English better justify this company in giving them more money? How many men have you today in this plant that were not on the payroll at the time of that last increase? Were not the men just as busy then as now? Have you any more or different machines now? Has the output increased enough to make it perceptibly harder for any man to do his daily work, and have you had to hire any more men to meet this condition? What sort of repair jobs have come up that have been handled quicker than before by the men as the result of their greater familiarity with the station and at how much less cost? Don't you pay the 'going rate' of wages in this station?"

By this time the engineer is likely to be reduced to a point where a reply is impossible unless he has anticipated just such objections. There is no use in considering the manager as a leather-hearted tight-wad, for he is only trying to protect the investor, although sometimes protecting the investor and sharing the profits may be parts of the same policy.

H. S. KNOWLTON.

Cambridge, Mass.

Operating a Pressure Pump without an Accumulator

Some time ago we installed a large pump to maintain a pressure of about 2200 lb. on the rams of a number of hydraulic presses. The accumulator on the line between the presses and the pump was weighted by building a cement block upon it. Subsequently, it was found that the weight was insufficient, and after some careful figuring the fact was brought out that it would be necessary to remove the whole cement block in order to get room to put on the pig-iron weights that our pressure called for.

This looked like a big and expensive proposition, so I advised running without an accumulator. This was objected to by the superintendent, and to my surprise the pump agent sided with him, but later they told me to go ahead and try it. I am pleased to say that after a year's operation in this way, the pump is giving good service, and I have less trouble with it than with its mate, which is attached to an accumulator.

I calculated that 88 lb. pressure per square inch, acting on the 10-in. steam piston (having an area of 78.54 in.), exerted a total pressure of 6911 lb.; operating a 2-in. plunger on the water end against 2200 lb. per sq.in. would just balance. It was therefore necessary to raise the boiler pressure slightly to overcome friction.

This pump is of the single-cylinder type, and we experienced no trouble with it until about two months ago, when the pressure fell at each stroke, and as a uniform and constant pressure is called for in our work, it was necessary to find the cause. The piping and joints were examined for leaks, the packing was renewed, the valves in the pipe lines were tested, and the pump valves were removed and inspected, but still the pressures varied. I decided that the trouble lay in the discharge valves, but was unable to see what it was.

On Sunday I thought it would not be amiss to give the valves a little grinding, although they did not seem to need it by any means. The next morning the pump acted much better and the variation in pressure was much less. Here was the cause, and a very small cause it was at that. Since then I have made a thorough job of the grinding, and the pump is giving splendid service.

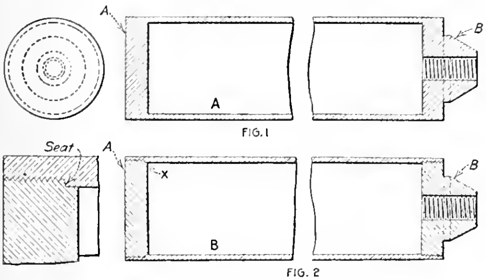
While grinding does not appear to change the surface of these valves, results show that it does. I believe grooves are caused by the action of the water under high pressure, and while they are not to be detected by the eye or touch, under a glass they are easily seen. Engineers who have not had such experience will be surprised to know how rapidly water under high pressures can get through minute holes.

A. D. Palmer.

Dorchester, Mass

Renewing Pump Plungers

The illustration shows a method of renewing the plungers of an outside-packed plunger pump. Those furnished by the manufacturer are of cast brass, the shell being from 1/4 to 1/2 in. thick, according to the size of the pump and the working pressure. Fig. 1 shows the original plunger and Fig. 2 the new one. The heads *A* and *B* were cut off, turned and threaded as shown in



Pump Plunger Made of Pipe

Fig. 2. The shell was replaced by a length of extra-heavy seamless bronze pipe, seated and threaded to take the heads *A* and *B*.

The cost of the new plunger, including material and labor, is one-half that of the one furnished by the manufacturer. This difference in cost is due to the fact that in making the castings there is always difficulty in keeping them free from blow-holes, and another irregularity, the shifting of the core.

The life of the cast-brass plungers does not in any way compare with those of seamless bronze pipe, and when the latter is worn down, it is only necessary to replace the shell.

Herman Fiebig.

Brooklyn, N. Y.

Crankpin Failure

Referring to the article by F. F. Jorgensen, on the subject of crankpin failures in the issue of May 25, on page 720, I consider that the pin was not large enough in diameter for a cylinder of the size given (24 in.). There is an approximate moment of $2\frac{1}{2}$ in., therefore,

$$55{,}000 \times 2\frac{1}{2} = 137{,}500 \textit{ in.-lb.}$$

The section modulus of $1\frac{1}{2}$-in. diameter equals $0.98 \times 1\frac{1}{2}^3 = 8.91$, say 9.

$$138{,}500 \div 9 = 15{,}278 \textit{ lb. stress per sq.in. of pin.}$$

This is too high a stress for such work as hoisting. The normal stress should not be more than half of this, say 7000 lb. per sq.in.

The fillets are good and should be on all such pins. A still better design is to countersink the collar in the crank from one-quarter to one-half inch, and more where possible. I would suggest that a larger pin be made and put in before another accident occurs, because a larger pin is really necessary, and no doubt the crankpin box is of such design that the bore can be somewhat increased.

R. G. Cox.

Cleveland, Ohio.

The addition of fillets is undoubtedly an improvement on the old pin that failed, but the main trouble is that the pin is too small for the load. The information given indicates that the maximum pressure upon the pin was 54,000 lb. and the fiber stress in the pin at the point where it broke was 15,100 lb. per sq.in. As the stresses in a crankpin occur twice in each revolution, it is necessary to use a low fiber stress, generally between 8000 and 12,000 lb. per sq.in., according to the grade of steel. Assuming a fiber stress of 9500 lb. per sq.in., the new pin should be $5\frac{3}{4}$ in. diameter. Heat-treated or alloy steel may, of course, be subjected to higher stresses. The impact load is sometimes very high, and this is an added argument for designing the rods and pins of such engines for low fiber stresses.

A. D. Williams.

Cleveland, Ohio.

It is evident that the absence of a fillet contributed much toward the failure. In locomotive practice, failures occur even with liberal fillets. I recall a series of pin failures on 18x24-in. eight-wheel engines on a Middle West railroad at one time. The engines were some eight years old at the time, and well cared for. The back pins broke off just inside of the pin hub, and the fractures as a rule resembled the illustration shown on page 720, May 25.

The principal part of the fracture was toward the center of the wheel, a smaller break was on the outside of the pin, and the pin hub was chafed bright for one-half to three-quarters of an inch in from the face of the pin hub, indicating a bending of the pin for some time prior to fracture. The face of the fracture being quite smooth at the outside of the pin and gradually becoming coarser toward the place of final rupture, shows the characteristic fracture of the material of which the pin was composed. The original wrought-iron pins were replaced by either wrought-iron or forged steel in different engines, but both of the new kinds broke, some in as short a time as six weeks. They generally broke about one-quarter to one-third of the pin's diameter before the final rupture took place.

After the failure of the new pins of the same size as the original, the pin hubs were bored one-quarter inch larger and case-hardened pins of Low Moor iron were put in. There were no more failures for about a year afterward while I was working there. The cause of the fractures was evidently due to the thrashing of the rods at high speed, although on that type of engine we did not have any trouble from breaking main pins, notwithstanding they carried the two rods and had the piston pull to reckon with. On another road I saw a number of main-pin failures, and the fractures showed the same general features.

When the brasses are removed, a coating of white-lead paint on a freshly wiped pin will disclose cracks, the paint becoming discolored by the oil in the cracks. However, this test will be of no value where the fracture is within the pin hub.

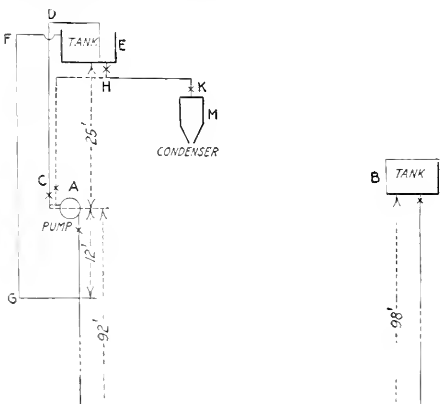
C. W. Haynes.

Rome, N. Y.

Centrifugal Pump Became Air Bound

The centrifugal pump *A* draws salt water from the tank *B*, through 590 ft. (400 + 92 + 98) of 12-in. pipe. When the machine is stopped there is about three pounds' pressure on the suction side at the pump.

The pump discharges through line *CD* into tank *E*. The latter supplies salt water to the condenser *M* through



Piping Diagram of Pump, Condenser and Tanks

pipe *HK*; *F* is an overflow pipe. This was intended to eliminate hand regulation of the pump discharge; if the quantity was too great it merely overflowed from the tank back through *F* into the suction of the pump. However, the water flowing back through *F* sucked in air. This was drawn through *F* into the pump, causing it to become air bound, and it would deliver no water.

Another thing contributing to the air binding was the fact that when the pump was working up to capacity there was a vacuum of about 15 in. at its suction due to the friction of the 590 ft. of piping. When this vacuum exceeded the head due to *BG*, air would be sucked in through the pipe *F*.

The above conditions were remedied by doing away with tank *E* and pumping directly to the condenser through pipes *CHK* (shown dotted) regulating the capacity by means of valve *K*.

Frank McMorrow.

New York City.

Sand for Hand Cleaning

Power-plant men usually have a hard time cleaning their hands. At our place we keep a supply of fine sand by the sink, which we apply to our hands after soaping them well. This takes the grease off without injuring the hands. I have always been troubled with chapped hands in the winter, but scouring them in the sand once or twice a day overcomes this trouble.

J. O. Benefiel.

Anderson, Ind.

An Unusual Piston Failure

In the issue of May 18, page 689, J. W. Dickson describes a unusual piston failure and asks to hear from readers who have had like experiences. A similar accident was related in Power about five or six years ago, and since then this has occurred twice in the plant of which I have charge. Both were in 22-in. pistons on low-pressure air compressors of different make. In neither case was any damage done to the compressor. In the first the damage was repaired in the way described by Mr. Dickson; in the second a new piston was required, which the builder supplied without charge.

No time was lost in finding the cause of the pounding, thanks to the article in Power, which was fresh in the writer's memory when the first failure occurred. The trouble in each case was due to core iron (used to stiffen the sand core) being left in the piston when it was cleaned, this cleaning out of the core being a difficult matter on account of the small opening provided for the purpose. The pounding was caused by the increased clearance volume.

P. L. Werner.

McKeesport, Penn.

One morning a number of years ago, a sudden loud "thump" inside of our 16x36-in. engine shook things up pretty well. The chief shut the engine down promptly, took off the cylinder head and found that a nut from one of the adjusting bolts between the bull ring and piston had worked off and worn a hole through one head of the piston and nearly through the other. These places were drilled out and plugged, after which the engine ran as well as ever.

Later we had an experience on a condenser pump similar to that described by Mr. Dickson and repaired it in the same way.

W. O. Perkins.

Bristol, Conn.

We had a very similar accident with a straight-line steam compressor. The piston in the steam end was of the built-up type, and two of the centering capscrews worked loose. One wore through the follower plate (which was one inch thick), fell out into the crank end of the cylinder, and broke the follower plate. A new cored piston was cast and put in place of the built-up type, and the compressor has since been running very satisfactorily.

P. F. OATES.

Santa Barbara, Chih., Mexico.

A Warning Sign

The illustration shows a safety or danger sign used in our plant. When the men go to work on shafting or belts they are instructed to hang this sign on the throttle valve and waterwheel gate as a warning to the engineer and others not to start any prime mover, and every man working on the job must sign his name on a pad near-by. When he has finished with his work he must cross out his name and the last man off the job is to take the sign or signs down. Our danger sign is 8x23 in., made of galvanized iron painted with aluminum, with a red border and red letters.

METAL DANGER SIGNAL

A. D. SKINNER.

Chadwick, N. Y.

Peculiar Induction-Motor Accident

I was called upon recently to repair a motor that had met with a rather unusual accident. It was a 100-hp., three-phase, 440-volt machine operating a gyratory crusher in a rock quarry. Heavy rains had caused a slide, and a rock had fallen from the quarry face through the motor room, breaking one of the leads to the auto-starter. This caused the no-voltage release to act, cutting out the motor at the auto-starter. A greater mass of rock was loosened by the first slide, and about five hundred tons crashed through the motor room, covering the motor entirely. In a short time smoke was seen coming up through the débris, and someone cut off the power at the quarry substation. Upon uncovering the motor, it was found apparently uninjured, but the auto-starter was seen to be in the "starting" position. Upon test, the motor showed forty badly burned coils.

Investigation showed that the first slide had cut out the motor safely, but the second slide (only a few seconds later) must have struck the auto-starter handle so as to throw it into the "starting" position, and to wedge it there. The motor could not start for at least two reasons: First, because one lead had been broken by the first slide, leaving the motor on single-phase; and second, because the machine was blocked by the rock from the second slide. The auto-starter was so wired that there were no fuses on the starting side, and the substation fuses were too large to relieve the motor, so it had to stand with the one phase hot, causing damage to forty coils. The auto-starter was uninjured.

The worst coils were cut out, and the others repaired so that the motor was put into commission 14 hours after the accident.

D. D. SMALLEY.

Bagley, Calif.

Single-Unit Power Plants

A short time ago the writer was asked to investigate the proposition of installing a municipal electric-light plant in a small town, and after determining as nearly as possible the probable load, it was decided that the conditions would warrant the installation of two 75-kw. units.

Several types of plants were considered, but the one which attracted special attention was the proposal to install a 125-hp. anthracite gas producer and a 100-kw. generator, to which would be connected two 2-cylinder gas engines of 70 hp. each, one on either end of the generator and connected thereto through a clutch. The principal advantage claimed for this arrangement was that, the gas engine being uneconomical at light loads, either engine could be used separately when the load was light, thus increasing the load factor toward the most economical point. Then, as the generator load rose above the capacity of one engine, the other could be cut into service and both run in parallel. It was claimed that this plan had been tried and found successful, even when running alternators in parallel, and that no trouble was experienced in the regulation.

The load to be handled was residence, store and street lighting with a small intermittent motor load on the water-works pumps. It would average about 50 kw. at the start, with a peak during the evening. The system arranged in this manner would allow one engine to be operated during the regular load, alternating every day and using both on the peak. This would also give time to keep the engines in good running condition.

Another advantage claimed was that, as only one generator would be used, the first cost would be less, including a smaller switchboard and less wiring. It was further proposed that when the load had increased to an average of 80 or 100 kw., a second unit consisting of one engine and one generator (with an additional producer) could be installed and operated at about full load. The combination unit would then be held as a reserve and used to help out on the peak load, running one or both engines as the conditions required. This plan would insure the engines' being fully loaded at all times and would reduce the coal consumption per kilowatt-hour to the lowest point.

Arguments that may be advanced against this plan are that the system consists of outside pole lines and there would be considerable danger from lightning. The generator and switchboard would of course be protected by lightning arresters, but there is a possibility that the generator might be damaged from this source, which would put the entire plant out of commission. An alternating-current generator as a rule is not as liable to be damaged, in the machine itself as a direct-current machine, there being no commutator; but trouble might develop, either in the machine itself or in the exciter, which would put the entire plant out. It is probable that no breakdown service could be provided, as the idea is to take the load away from the central station at the expiration of the franchise.

Another proposition was to install two 100-hp. boilers and one Corliss engine to operate at 125 lb. and 150 r.p.m., and direct-connected to the generator. The builder claimed that this arrangement could be depended on to run 18 or 24 hr. a day, 7 days a week, and with only a few minutes' stop once or twice a week for keying up and other minor adjustments. This would fill the requirements of the plant for several years to come or until money was available for a second unit. It must be remembered that these plans were not advocated as being the best, but to get a plant with the money available at the time the central-station franchise expired.

The greatest objections to this single-unit steam plant in addition to generator trouble is that in order to carry the peak and the increasing average load, it would be considerably underloaded a greater part of the time, and the steam consumption would be correspondingly high.

The matter has not yet been settled. Usually, it has been considered poor policy to depend on one unit for continuous operation, although the writer knows of several instances where this was done for a number of years, and the engine, as a rule, was stopped only half an hour at noon once a week, running 24 hr. a day and carrying approximately full load.

J. C. Hawkins.

Hyattsville, Md.

Another Combustion Suggestion

There appear to be two principles that might be used to improve the action of boiler furnaces in addition to those already utilized. They have been used in analogous arts and might be availed of to make the combustion of the fuel used with boilers more efficient.

The first is based on the old method of brightening a fire by means of a poker or iron. It consists in placing the iron in a dull fire where the combustion is most prominent and leaving it there. The iron accumulates and stores the heat and not only prevents the fire from dying out, but conveys the heat to other parts of the fuel. It also takes up heat that would otherwise pass off in the gases. When the iron becomes red-hot it acts like a burning coal, except that it does not burn out and stop heating.

This principle could be used in boilers by placing a number of rods across the furnace so they would come in contact with the fuel above the grate. They could even be extended along the path of the furnaces through the boiler parts, so that the gases would have heat supplied to them during the entire period. The rods, being conductors, would supply heat to the gases at all points at about the same temperature as they (the rods) were at, in the furnace. The rods would deteriorate, but that would not of itself be an argument against their use.

If the rod was hollow, particularly in the portion that was in the furnace, it could be used to convey the draft or air to the furnace where it was needed and without cooling the fire, and at the same time the air would tend to keep the rod sufficiently cool to prevent melting.

The second principle consists in using materials that will raise the temperature of the fire and that do not burn themselves—for instance, chalk, unglazed ware, etc. This principle is like that used in an incandescent gas burner. It might be employed by mixing the material with the fuel or by installing it in some back part of the furnace so as to heat the gases or promote combustion in some special part of the boiler. In any case, it would serve to increase the efficiency of the fuel used and to stabilize the operation of the boiler in somewhat the same way that a flywheel does the action of a reciprocating engine.

These are theoretical suggestions. Can they be made of practical use?

A. P. Connor.

Washington, D. C.

Differential Draft Gage

Differential draft and air-supply gages are inexpensive in comparison with the saving they represent. Time is well spent in their upkeep. Imperfect connections to furnace or ashpit thwart their purpose.

Water has too variable a capillarity to be employed as an indicating fluid. Kerosene may be used in an emergency. The best liquid is a mineral oil of 39 degrees gravity, Baumé scale, at 60 deg. F. and specific gravity about 0.834. This oil evaporates slowly, is a good lubricant and will recede to the zero mark. To set the differential gage both ends should be free to the atmosphere. The liquid should be poured carefully into the reservoir end until the zero mark has been reached.

No set of rules can be laid down as to the amount of draft to be carried, as load, fuel-bed thickness and other factors affect each case differently. A near approach to a balance seems to be the aim in many plants. It is true that a high degree of perfection in combustion can thus be attained and a high CO_2 record made, but for practical operating conditions I prefer at least 0.02 or 0.03 in. of water over the fire. Of course, a pressure of 0.06 or 0.07 in. or even 1.02 in. under the fire will do no harm if the firebed is well sealed.

Edward T. Binns.

Philadelphia, Penn.

Removing Scale from Oil-Engine Jacket

Operators of oil engines often experience trouble with the cooling water scaling up the cylinder jackets; in fact, in some localities the jacket almost fills with scaly deposits in a few weeks. The method usually employed is to allow a dilute sulphuric-acid solution to remain in the jacket for a few hours, thereby loosening the scale. This is effective, but rather severe on the cylinder walls.

A short time ago the writer met with this trouble and eliminated it by using graphite mixed with oil and placed in an ordinary hand oil pump connected to the cylinder jacket. The engineer operating this engine gives the pump two or three strokes a few times each day. It seems that the graphite acts upon the jacket in the same manner as on boiler tubes.

L. H. Morrison.

Fremont, Neb.

Inquiries of General Interest

Estimating Piston Speed of Duplex Pump—In a duplex pump how is the piston speed determined from the length of stroke and the number of revolutions per minute?

F. P. K.

The term, piston speed, has reference to the average velocity of the water pistons, and when each side makes the same length of stroke the average piston speed in inches per minute would be found by multiplying the length of stroke in inches by two, and by the number of revolutions per minute. This product divided by 12 would be the average piston speed in feet per minute.

Drilling Small Holes in Glass—What is a good method of drilling small holes in glass?

G. W. K.

Small holes can be drilled in glass by employing a flat drill lubricated with turpentine. In drilling small holes through thin glass, care should be taken that the drill does not break through and therehy shatter the glass. Where possible, the drilling should be done from both sides. Another method is to employ a drill made of brass pipe having its end cut off square and one or more slots in its side for the introduction of flour of corundum.

Stability and Isochronism of Governors—What is the difference between stability and isochronism of steam-engine governors?

G. R.

A governor is said to be stable when it assumes a definite position for each particular speed and when a change of speed is necessary for a change of position, while a governor which is in equilibrium at but one speed is said to be isochronous. Perfect isochronism would be impractical, as the slightest increase in speed above the normal would result in cutting off the steam, accompanied by a sudden decrease of speed, following which the steam valve would open wide, thus giving rise to extreme fluctuations.

Water Hammer in Steam Pipes—What is the explanation of water hammer in spaces containing steam, and particularly the snapping and cracking noise often heard in steam pipes?

R. W. R.

Water hammer is attributed to the impact of particles or slugs of water upon each other or against the sides of a pipe or other containing vessel, due to the formation of vacuous spaces that result from cooling and condensation of the steam. Water is comparatively incompressible, and a continuation of the high velocity of the steam toward such a vacuous space after condensation has taken place and the movement of slugs of water toward those spaces at high velocity by the elastic force of the steam result in violent impacts, similar to those occurring when inelastic bodies impinge upon each other at high velocities.

Size of Steam Pipe—Allowing a velocity of 5000 ft. per min., what diameter of steam pipe would be required to pass 6500 lb. of steam per hour at a gage pressure of 80 lb. per sq.in.?

B. E.

Referring to the steam tables, it is found that the specific volume of dry saturated steam at 80 lb. gage, or 95 lb. absolute, is 4.65 cu.ft. per lb., and as the flow would be

$$6500 \div 60 = 108.33 \text{ lb.}$$

of steam per min., the volume flowing per minute would be

$$108.33 \times 4.65 = 503.73 \text{ cu.ft.}$$

and the required cross-sectional area of the steam pipe for a velocity of 5000 ft. per min. would be

$$\frac{503.73 \times 144}{5000} = 14.5 \text{ sq.in.}$$

which corresponds to

$$\sqrt{\frac{14.5}{0.7854}} = 4.28 \text{ in.}$$

diameter, and therefore 4½-in. steam pipe would be the nearest commercial size suitable.

Relative Merits of Belt Dressings—In what particulars should the relative merits of belt dressings be considered, and how can they be practically compared?

E. W. C.

The leading merits of belt dressings consist in (1) increasing the coefficient of friction between the belt and the pulley, enabling transmisison of a given power with a lower belt tension; (2) increasing the pliability, and (3) prolonging the life of the belt. The relative friction can be practically determined by treating each half of the length of a belt with one of the dressings or by applying the dressing to only one half for comparison with an untreated half, and, with the belt in use, observing which half first shows slippage when the belt is gradually loaded to its transmitting capacity. Or, after use for some time, the relative coefficients of friction can be approximately determined by alternately hanging the belts over the same pulley, and determining which condition requires the greater load to be suspended from the belt over one side of the pulley to slip the belt in raising a given weight suspended from the belt over the other side of the pulley. Relative pliability is made apparent by observing which belt forms a smaller loop when folded over on itself, or when equal lengths of each belt are gathered and suspended. The effect of dressing on durability of a belt can only be determined by test of time and usage.

Volume of Air for Burning a Pound of Coal—What volume of air is required for combustion of a pound of coal?

J. R.

The weight of air required is given approximately by the formula,

$$\text{Weight of air in pounds} = 12C + 35 \left(H - \frac{O}{8}\right)$$

in which C, H and O represent the parts of a pound of carbon, hydrogen and oxygen in a pound of the coal.

Applying the formula to the analysis of most coals will show that about 12 lb. of air is required for combustion of a pound of the fuel, and as one pound of air at 62 deg. F. has a volume of 13.14 cu.ft., then 12×13.14, or about 158, cu.ft. of air will be required to burn each pound of the fuel. For certainty, however, that the carbon will meet with an abundance of oxygen, it becomes necessary to admit an excess of air, depending on the draft, and the weaker the draft the more the excess required. Hence, with chimney draft it is usual to supply about 300 cu.ft. of air per lb. of coal, and with forced draft about 200 cu.ft. of air per lb. of coal.

Discharge of Water from Hydrant—What quantity of water would be discharged per minute through a short 2-in. pipe connected to a fire hydrant in which the pressure is 60 lb. per sq.in.?

M. A.

The rate of discharge would depend upon the roughness and length of the pipe and the pressure at the entrance of the pipe. Assuming that the pressure 60 lb. per sq.in. is maintained while discharge is taking place, then as 60 lb. per sq.in. would be equivalent to

$$60 \times 2.3 = 138 \text{ ft. head}$$

and as the theoretical velocity in feet per second due to the head would be given by the formula,

$$v = \sqrt{2gh}$$

in which

v = Velocity in feet per second;
g = 32.16, the acceleration of gravity;
h = 138;

then,

$v = \sqrt{64.32 \times 138}$, or about 94.2 ft. per sec.

If the pipe has a smooth bore and a length 3 to 3½ times its diameter, that is, 6 to 7 in. long, and has a smooth, square entrance end, then the actual velocity of discharge will be about 81 per cent. of the theoretical, and as the cross-sectional area would be

$$2 \times 2 \times 0.7854 = 3.1416 \text{ sq.in.}$$

the discharge would be approximately

$$\frac{0.81 \times 94.2 \times 12 \times 3.1416 \times 60}{231} = 747 \text{ gal. per min.}$$

It is assumed that the pressure at the entrance of the 2-in. pipe is ascertained from indication of an accurate pressure gage during the discharge, as that pressure is not to be confused with the static pressure which exists only when no discharge is taking place.

National Electric Light Ass

With a registration of over one thousand, the thirty-eighth annual convention of the National Electric Light Association at San Francisco, June 7-11, was an unqualified success. The eight-story building, "Native Sons of the Golden West," served as headquarters for registration and meetings, and the Hotel St. Francis, adjoining, cared for most of the delegates and was the center of the social features of the convention, especially the reception given on Monday night by the president, H. H. Scott. On the same evening was dedicated the "Temple of Light," an Ionic colonnade erected around the Dewey monument in Union Square. This was turned over to the visitors by John A. Britton on behalf of the local members, and President Scott accepted it on behalf of the convention.

At the opening session on Tuesday morning, the visitors were greeted by Mayor Rolph, of San Francisco, and by John A. Britton, general manager of the Pacific Gas & Electric Co., who briefly outlined the progress of the Pacific Coast States, with special reference to the important part played by electricity in their development.

Response was made by President Scott, who in the course of his address pointed out the great decrease in the price of electric service during the past 15 years, whereas the price of most commodities had increased. This had been due to increased efficiency in production and to more efficient lighting, the public having derived the benefit.

The remainder of the morning was taken up with the reports of the secretary and of several committees. T. C. Martin, as chairman of the Committee on Progress, dealt with the present conditions of the electrical industry, pointing out a steady increase in spite of the recent business depression, although there have been practically no additions to the number of large central stations during the past year. The second part of the report (read at the hydro-electric session) was devoted to hydro-electric and transmission work, and discussed the pending national legislation on conservation. It suggested that the law be framed so that the banker shall know reasonably well to what extent the investor is protected and to what extent he must accept risk. Opinions were quoted from a number of men associated with hydro-electric work, notably Hugh L. Cooper, who stated that within the past 10 or 12 years hydro-electric plants aggregating over 600,000-hp. capacity had either been through receivership or had proved bad investments.

FIRST TECHNICAL SESSION

The first technical session was held on Tuesday afternoon, at which were read the reports of the committees on Meters, Electrical Apparatus, and the Grounding of Secondaries, as well as two papers—one on "Application of the Diversity Factor," by H. P. Gear, and the other on "Features of the Lighting of the Panama-Pacific Exposition," by W. D'A Ryan, illuminating engineer of the Exposition.

In the report on electrical apparatus, attention was called to the introduction of the phase-advancer in performing the same functions as the synchronous condenser in connection with inductive motor loads. While condensers serve primarily for regulating a complete installation, the phase-advancer provides an economical means for regulating the power factor of an individual motor. Among the recommendations of the committee were the use of electrolytic arresters with rotary converters and suitable methods of grounding the converter frames. Modifications of the rules of certain member companies to conform to those of the majority with regard to motor connections was urged, as this would greatly simplify the problems of manufacturers and distributors of standard commercial motors.

FIRST ACCOUNTING AND COMMERCIAL SESSIONS

Simultaneously with the first technical session were held the first accounting session and the first commercial session. The order of business of the former included an address by the chairman, H. M. Edwards, and reports from the Library Committee, the Question Box Committee, the Committee on Uniform System of Accounts, and a paper by L. R. Reynolds on "Some Opportunities of Public-Utility Accountants."

The commercial section, after listening to an address by the chairman, Douglas Burnett, heard the reports of the committees on Foreign Relations, Finance, Publications, the Education of Salesmen, and the Commercial-Department Terminology.

On Wednesday morning the association listened to an address by President Moore of the Panama-Pacific Exposition, who reviewed the hydro-electric development on the Pacific Coast and spoke of the electrical illumination at the Exposition. He said that about 850 conventions had chosen San Francisco for their place of meeting this year.

Following President Moore's address were held the first hydro-electric and second technical sessions, the second commercial session and the second accounting session. Chairman Wagner called to order the hydro-electric and technical sessions and the report of the Hydro-electric Committee was read by Mr. Downing, in the absence of the chairman, R. Bump.

REPORT ON PRIME MOVERS

The report of the Committee on Prime Movers was next read by Mr. Coldwell, in the absence of Chairman Moulthrop. The report called attention to the improvements in the design of surface condensers during the past year and also to the increased economy obtained by large steam turbines. Two new stokers of the underfeed type for high capacity were described, and considerable space was devoted to the subject of economizers. The steady increase in the rate of evaporation, with a consequent increase in the volume and velocity of the flue gases and a somewhat higher temperature at the boiler exit, together with the improvement of condensing apparatus, producing lower vacuum and lower hotwell temperatures, have created conditions more favorable to the use of economizers. Under "Gas Power," figures were quoted to show that there are vast quantities of fuel-oil in the United States and in Mexico and that there is much activity in Diesel-engine work among American manufacturers. The gas-engine situation however, seems to be little changed from that of last year; this also applies to the gas producer.

In discussing the report, Henry Hull, of the Puget Sound Traction, Light & Power Co., of Seattle, stated that it had been the experience of his company in burning low-grade, highly volatile lignites, such as are available on the Pacific Coast, that the best results were obtained by the use of continuous chain grates of large area installed in furnaces with dutch ovens. He believed it imperative that the coal be of uniform size to prevent occurrence of holes in the fuel bed and to secure a uniform fire; also that it is necessary, in using a chain grate, to employ a free-burning coal, as any tendency to coke will give trouble from jamming and piling up at the back of the furnace.

ciation At The Exposition

In the speaker's opinion, the use of economizers depends entirely upon the individual conditions. In plants operating with steam-driven auxiliaries and where leaks in boiler settings are minimized and baffling kept tight, the advisability of installing economizers appears doubtful. He believed that if more attention was given to utilizing the heat in the boiler itself, the results would tend to offset the desirability of the economizer.

A written discussion by Professors Rosencranz and Phillips, of the Oregon Agricultural College, dealt with the control of combustion when burning oil fuel. The authors pointed out that the combustion of oil is practically an instantaneous process, and assuming the ratio of oil to air to be correct with a uniformity of mixture and the proper combustion space, maximum efficiency of combustion will result. An instrument showing the instantaneous rate of flow of the air and oil to the furnace would go far to solve this problem. The CO_2 recorder has been a big help in this respect, but it is handicapped by the fact that it is from three to ten minutes late in its indications, which is a disadvantage on variable loads. It was pointed out that the boiler itself could be made its own gas or air meter by attaching a differential draft gage, one end to the combustion space and the other end beyond the last pass. This would measure the boiler resistance, which will be different for every rate of flow, and hence be an indication of the rate of gas flow through the boiler.

Mr. Philip Torchio, in discussing economizers, gave the results of some observations made in Europe about a year ago, to the effect that a considerable saving, probably as high as 8 per cent. in fuel consumption, was possible under certain conditions by the use of economizers. However, the whole equipment of the station must be laid out for such use of economizers. He believed that in this country it would probably be difficult to apply the economizers without changing the auxiliaries and drafts of the boilers, which would make the problem quite expensive. In new stations, however, he believed that economizers could be used profitably by designing them for use with the stacks of the Epozee type, in which air is blown into the stack and creates a draft as in the case of a steam injector. He called attention to the difference between European and American practice, in that the former employed motor-driven auxiliaries almost exclusively.

F. H. Varney, of the Pacific Gas & Electric Co., discussed the use of soda ash in the boilers, his contention being that if air is kept out of the boilers there is no need for soda ash to prevent pitting. For this reason his company has adopted the open type of heaters.

Appended to the Prime Movers' report was a paper by C. M. Allen, which discussed weirs, current meters, pitot tubes, venturi meters, floats, waterwheels and meters, the moving-screen method of measurement, and the salt-solution method. Briefly, the latter method consists of discharging a known amount of salt solution into the water before it passes through the wheel, then analyzing the water as it discharges from the wheel, and from accurate chemical analysis determining the total amount of water discharged by the wheel. Another method was also cited, of injecting color into the conduit close to the forebay and measuring the time elapsed until the color appears in the tailrace.

Professor Peaslee, in discussing Mr. Allen's paper, described a conductivity meter for measuring the flow by the salt-solution method without chemical analysis.

The next paper was entitled "Practice in High-Head Hydraulic Plants," by J. P. Jollyman, of the Pacific Gas & Electric Co., who reviewed the present practice along the Pacific Coast, pointing out that this favors the use of steel pipes with either riveted or welded joints. Expansion is usually provided for by long-radius bends, rather than slip joints, which are employed only where the pressure is not excessive. For heads up to 700 ft. and specific speeds as low as 12, Francis turbines were recommended, and impulse wheels for heads up to 3000 ft. or over, with specific speeds as high as 4 for heads up to 2000 ft. He considered the most desirable speed for waterwheel-driven generators of 3000 to 15,000 capacity to be about 400 r.p.m.

In discussing Mr. Jollyman's paper, M. T. Crawford referred to two 10,000-kw. generators in the White River plant of the Puget Sound Traction, Light & Power Co., which were originally fitted with the usual fan type of rotor for sucking air along the shaft and forcing it out through the windings on the stator. With this equipment the machines carried a rated load with a normal temperature rise of not over 40 deg. C. above the incoming air. It was found, however, that on warm summer days the temperature of the air to the generator room reached as high as 35 deg. C., and any overloading of the machines would give a fairly high temperature in the windings. Accordingly, the generators were inclosed and the incoming air taken from inclosed spaces above the tailrace outside the building. A number of spray nozzles are kept playing in these inclosed spaces, so as to greatly increase the humidity, and the air goes in at a temperature of about 17 deg. C. The generators can now be operated satisfactorily at 40 per cent. overload, and the temperature is cut down to 40 deg. between the laminations and the incoming air.

"Analysis of Waterwheel-Governor Efforts" was the subject of a paper by E. D. Searing. This gave a résumé of an interesting series of experiments made in analyzing a governor problem at one of the hydro-electric plants of the Portland Railway, Light & Power Co. Steam-engine indicators were connected to each end of the governor cylinder of the waterwheel unit, and continuous records of the varying pressures from each side of the governor piston throughout one cycle of operation were obtained. An analysis of the effort of separating friction and unbalance was made, and the rise of pressure in the wheel casing, high pressures in the governor cylinder, overspeed devices and wicket gates themselves, were thoroughly studied.

The next paper was on "Oil-Burning Standby Plants," by C. H. Delany, of the Pacific Gas & Electric Co. This paper will be abstracted in a later issue. In discussing Mr. Delany's paper, E. A. Weymouth mentioned an installation at the plant of the Inspiration Copper Co., in which the boilers are equipped with steel casing and most thoroughly insulated. The boiler efficiency at three-quarters load is higher than at full rating, and at one-half load it is higher than at three-quarter load. This is explained by the fact that radiation is much greater in the case of the ordinary brick setting; and as it is a practically constant quantity for all loads, at light load it will be proportionately greater. The absorption of heat by the heating surfaces is better at light load, but with a brick setting the radiation loss offsets this. With the steel casing, however, and a proportionately less radiation loss, this does not hold true to such an extent, with the result that the efficiency is nearly 2 per cent. better at half load than at full load.

The last paper of this session was by D. M. Downing, on the "Water-Power Development on the Pacific Coast." This gave a general review of the whole subject and was fully illustrated.

SECOND COMMERCIAL AND ACCOUNTING SESSIONS

The second commercial session, also held on Wednesday morning, took up the report of the Committee on Sales Development in the West, and that of the committee on Merchandising and Recent Development of Electric Appliances. At the second accounting session, an interesting paper on "Workmen's Compensation Insurance" was read by Walter G. Cowles, vice-president of the Travelers Insurance Co. He expressed the opinion that the stock-insurance system is the only one that furnishes reliable means for reducing future losses to present fixed values. "European practice," he said, "along compensation lines, can teach us little or nothing, because the conditions there and here are widely different."

Following this was a paper on "Electric-Vehicle Cost Accounting," by W. P. Kennedy, and another on "Record of Property or Construction Expenditures," by T. R. Ferguson.

SECOND HYDRO-ELECTRIC AND THIRD TECHNICAL SESSIONS

The hydro-electric and technical sessions were continued on Wednesday afternoon, the order of business including the report of the Committee on Overhead Line Construction, a paper on "Electric Line Distribution in the Pacific Northwestern States," by J. C. Martin, the reports of the Hydro-Electric Sub-Committees on "High-Tension Transmission and Construction," on "High-Tension Apparatus," and on "Main-Line Electrification of Railroads."

On Thursday morning the fourth and concluding technical session took up the report of the Committee on Terminology and that of the Committee on Street Lighting, the latter prepared by J. W. Lieb, of the New York Edison Co., covering a digest of the information made available through an investigation of the street illumination which has been conducted in New York during the past year. M. J. Insull presented the report of the Committee on Accident Prevention, and Mr. Torchio that of the Committee on Underground Construction. The final paper of the session was on "Opportunities of the Public-Service Company in General Accident Prevention," by C. B. Scott, of the Chicago Middle-West Utilities Co.

The third accounting session considered the report of the Committee on Cost Accounting, a paper by O. B. Coldwell on "Analytical Accounting for Central-Station Purposes," and another paper by W. E. Freeman, on "Statistical Machines."

Reports of the Rate Research Committee and the Power Sales Bureau were considered at the fourth commercial session, as well as three papers—"The Commercial Application of Resistance Furnaces," by C. W. Bartlett, "A Stassano Furnace Installation at Redondo," by W. M. McKnight, and "Electric Furnace Power Loads," by F. T. Snyder.

On Thursday evening the Public Policy meeting was held, at which the report of the Public Policy Committee was presented by W. W. Freeman, and addresses were made by Max Thelen, of the Railroad Commission of California, and by John H. Roemer, a former member of the Wisconsin Railroad Commission.

ENTERTAINMENT FEATURES

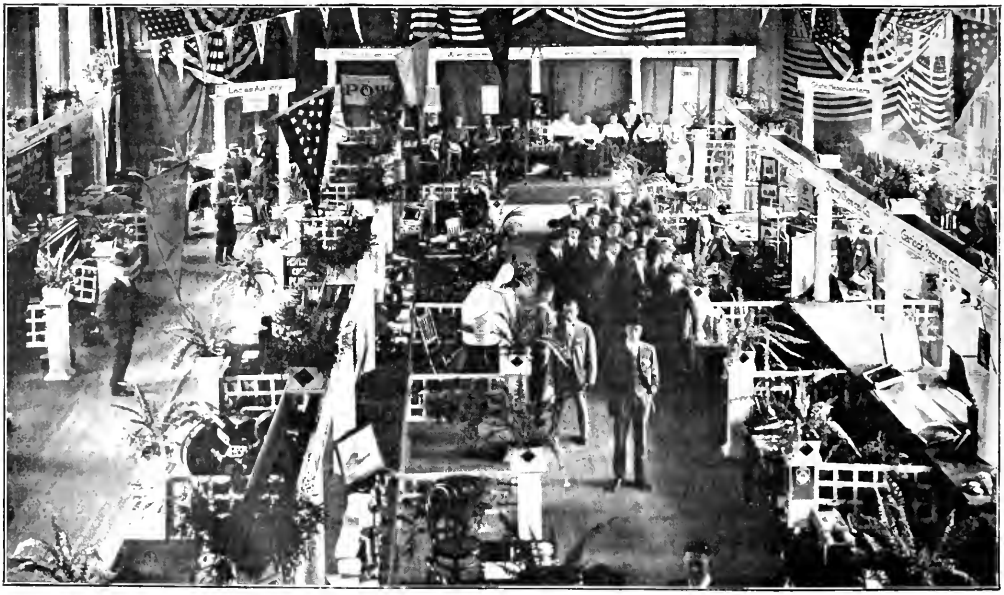
Members of the National Electric Light Association attended the Exposition in a body on Thursday afternoon, where a photograph was taken in front of the Tower of Jewels. The ceremonies were held in Festival Hall, and addresses were made by President Moore of the Exposition, President Scott of the Association, Samuel Insull, Arthur Arlett and Mayor Rolph; and greetings were read from Thomas Edison, Alexander Graham Bell, Elihu Thomson, Frank J. Sprague, Charles P. Steinmetz, Charles M. Brush, and J. J. Carthy. President Moore presented President Scott with a bronze medal commemorative of the convention.

The entertainment features also included a musicale and tea for the ladies on Wednesday afternoon, an automobile trip Thursday morning and luncheon at the Cliff House, after which they joined the men at the Exposition in the afternoon. Friday was spent on an all-day sightseeing trip to Mount Tamalpais and the Muir Woods. Special credit is due to F. H. Varney, chairman of the local entertainment committee, for unusual thoughtfulness in providing for the comfort and convenience of the guests.

E. W. Lloyd, general contract agent of the Commonwealth Edison Co. of Chicago, was elected president of the association for the coming year.

New Jersey N. A. S. E. Convention

While it was generally known that the Trenton convention of the New Jersey N. A. S. E. would consider important association affairs, no announcement had been made that the exhibit was to be one of the best-arranged and attended displays of engineering supplies ever connected with a state convention of the association. The exhibit, held in Masonic Hall, was opened to the public on Thursday, June 3, by Mayor Frederick W. Donnelly, with an address of welcome. A feature of the opening evening was an automobile tour of the



New Jersey N. A. S. E. Convention Exhibit Hall city "engineered" by the Mayor and Frank V. Tuthill, of the McLeod & Henry Co., and enjoyed by a number of engineers and supplymen.

The business sessions were held June 5 and 6 in the Trenton House, with Charles Sumner, president of the association, in the chair. About a hundred delegates attended. National Vice-President Walter Damon, of Springfield, Mass., and James Taylor, secretary-treasurer of the Life and Accident Department of the association, addressed the delegates during the Saturday session.

The Educational Committee reported that depressed business conditions had caused a slight lull in the educational activity of the various local associations; this was not serious, however, as the state committee had made special efforts to keep the smaller and most-in-need-of-help associations interested, with the result that their educational work on the whole was more commendable than that of the larger associations. The committee expressed the belief that there was no more thorough and inexpensive way of creating educational interest than by question-and-answer contests held by each association. Many associations have received valuable assistance from a pamphlet written by the instructor for Newark No. 3 Association. These "Examination Questions" are to be obtained by addressing No. 3 at 103 Market St., Newark, N. J.

The Legislation Committee handed in a short report at the Sunday session. A. L. Case, chairman of the board of examiners of the State Engine and Boiler Operators' Bureau, pointed out some of the defects in the present license law and read passages from a proposed bill that was vetoed by the governor. The law as it now stands reads that "the provisions of this act shall not be construed to include or apply to men holding marine licenses or to men in plants under the jurisdiction of the United States Government, or to locomotive engineers." Many of these engineers were refused licenses because the attorney-general handed down an opinion that they could not be lawfully given to them. The law needed amending when an engineer holding a license to run a dinky tugboat could operate the largest plant in the state and be immune from any action the license bureau might take. The vetoed bill also provided for a well-deserved increase in the salaries of examiners, from $1200 to $2000 a year. The convention adopted a resolution introduced by Newark No. 3 which embodied the amendments needed in the present law and stated that the governor's veto of the bill was the result of snap judgment. This resolution was ordered printed and circulated.

The next convention of the New Jersey State Association will be held in Paterson, N. J

Both Joseph Carney and William Reynolds, members of the National Board of Directors, refuted the rumor that the "National Engineer" was subsidized by central-station interests. A resolution was passed and ordered circulated embodying their denials.

Saturday a smoker and cabaret were given by the supplymen under the direction of Frank Martin, of Jenkins Bros., at which, among others, appeared the well-known but always entertaining trio—Jack Armour, Billy Murray and Herbert Self. The new officers elected are: President, Dennis Bartley, of Jersey City; vice-president, Thomas Brown, of Newark; secretary, James S. Heath, reëlected; treasurer, William Krause, of Passaic. During the convention the ladies sold cigars, candy and tags and otherwise added to the pension fund for indigent engineers. Mrs. McCoy, state deputy for the ladies' auxiliary, gave an interesting report of the doings of the state and national bodies.

A list of the exhibitors follows:

Albany Lubricating Co.
Cherry Chemical Co.
Corbett, E. A.
Crew, Levick & Co.
Crook & Son, A M
Dearborn Chemical Co.
Dick, R. & J.
De Laval Steam Turbine Co.
Engineering Supply Co.
Fisher & Norris.
France Packing Co.
Garlock Packing Co.
Greene, Tweed & Co.
Home Rubber Co.
Homestead Valve Co.
Industrial Requirements Co.
Jenkins Bros.
Johns-Manville Co., H. W.
Keystone Lubricating Co.
Lunkenheimer Co.
McArdle & Co.
McLeod & Henry Co.
Morehead Manufacturing Co.
"National Engineer"
Ohio Blower Co.
Otis Elevator Co.
Peerless Rubber Manufacturing Co.
Philadelphia Grease Co.
"Power."
Quaker City Rubber Co.
Reeves-Cubberley Engine Co.
Clement Restein Co.
Richardson Scale Co.
Robinson Co., W. C.
Roto Co., The
Roebling's Sons Co., John A.
Squires Co., C. E.
Stahl, Harry E.
Standard Regulator Co.
Steam Appliance Co.
Underwood & Co., H. B.
Webb & Sons Co., Elisha.
Zurn Oil Co.

Following the schedule of fittings and flanges published on page 782, June 8, 1915, the address of the National Association of Master Steam and Hot Water Fitters should have been given as 260 West Broadway, New York City.

Seventh Annual Convention of National District Heating Association

On June 1, 2 and 3, the seventh annual convention of the National District Heating Association was held at the Sherman Hotel, Chicago. The meeting was a great success. The papers and committee reports presented were of a high quality and indicated a vast amount of work in their preparation by practical men engaged in the heating business. The material presented was received with enthusiasm and discussed at length. The association has made wonderful progress since its inception six years ago, and a continuation of the present interest and enthusiasm will insure results of inestimable value to the field of district heating.

On Tuesday morning President H. R. Wetherell called the first session to order. Harry Miller, prosecuting attorney, in behalf of the mayor, welcomed the visitors to the city. The response was made by D. S. Boyden, first vice-president of the association. In his presidential address Mr. Wetherell believed the day had come when steam heating should not be regarded as a byproduct of the electrical end of the plant. It was up to the association to put heating on a paying basis. The public-service commissions of the various states were already insisting that the heating be made independent of the electrical plant so that the low rate formerly made in connection with lighting would be eliminated. By putting customers on a meter basis the consumption of steam would be greatly reduced over the old flat rate and the cost would be lowered to a reasonable figure. It was important to give strict attention to service and in every way possible satisfy the customer.

Secretary Gaskill reported the association in better financial condition than ever before and an increase of 44 members, which was 14.66 per cent. of the membership in 1914. He advised the election of honorary members and recommended that a suitable badge be presented to the retiring president. At the end of the session A. P. Biggs, chairman, presented the report of the station record committee. This dealt principally with franchises. Copies of franchises under which 25 different companies were operating had been obtained and the contents had been spread on a large data sheet, which was available at the convention. A collection and comparison of such data, it was thought, would eventually result in a standard franchise. A table on the steam consumption of various classes of building and the cost of trenching was in course of preparation and would be appended to the report before it appeared in the "Proceedings."

At the opening of the afternoon session J. F. Gilchrist, vice-president of the Commonwealth Edison Co., of Chicago, gave an interesting address on steam heating and the advantages of concentration in the generation of electricity and steam. As heat was one of the requirements of the race, it was evident that the heating business was founded on a solid foundation. It was one of the fundamental things human beings required, and in this respect was a little ahead of its big brother, the lighting and power business. In establishing central heating in Chicago, there had been no special foresight. The company had been forced to it. When they attempted to displace the isolated plant, it became evident that they must know something about the heating business and be in a position to furnish heat. The speaker explained how the Illinois Maintenance Co. had been founded in 1899 and how it had been built up to its present proportions. No comprehensive system had been laid out. It was arranged so that the electric-light contract for a building included the right to operate the plant in the basement to furnish steam for heating and to connect the plant with the piping of the adjoining building. Eventually, the piping was carried across alleys and in some cases streets, so that at the present time there are several plants taking care of a number of buildings. Mr. Gilchrist touched upon the importance of metering the steam, so that it would be to the interest of both the seller and user to minimize the consumption.

Although the possibilities of concentration in the heating business were not so great as in the generation of electric current, the following advantages were enumerated: The reduction of smoke, the possibility of obtaining high-grade labor from which higher economy might be expected, a decrease in the fire hazard and a reduction in the expenditure for handling fuel and ash.

In the United States 517,453,000 tons of coal was consumed per year. Of this amount central stations used 17,375,000 tons, street- and electric-railway plants, 10,078,000 tons; steam railways, 100,000,000 tons; and all other uses, 390,000,000 tons. Electric light and power and street railways only consumed 5 per cent. of the fuel. If the hydro-electric output was reduced to a steam basis this would account for 17,-

000,000 tons, so that the entire electrical output would only require 44,000,000 tons per year, or less than 10 per cent. of the total. The speaker expressed a desire to see a comparison of the work done in the different fields. It was certain that outside of the electric light and power business the coal is burned much less efficiently. Coal for domestic use was estimated at 50 to 100 million tons, leaving the remainder for heating and industrial purposes. By concentration much of this coal could be saved or at least be held to the same figure notwithstanding the increase of population. It was the speaker's opinion that there will in the next few years be a great development in the heating business. The importance of this service in connection with light and power will become greater in the years to come. The distribution of heat was a natural monopoly, and it should be permitted to act as such. It should be made independent of lighting and power and should come under the same regulating bodies as the central-station companies.

REPORT OF PUBLIC-POLICY COMMITTEE

Recognizing the desirability of all utilities following some form of general policy, the association has a standing committee on this subject. In the report presented the following items were briefly considered: Education of the public as to cost and advantages of heating service, extension, appraisal, rates, municipal ownership, legislation and franchises. The comments were general, leaving it to future years and committees to elaborate and definitely design the policies that should be pursued as conditions change and future developments require.

UNDERGROUND CONSTRUCTION

At the Wednesday morning session H. A. Woodworth presented the report of the underground construction committee, which was prepared to give the society the benefit of the best practice that the present day affords in the selection of materials and the installation and operation of district heating mains. Letters had been written to various companies affiliated with the association asking for particular data which they possessed. The replies showed a wide variation in the methods used throughout the country, and a study of the data indicated that these variations were not due to the geographical location or climatic conditions. It was clear that one of the greatest needs was a closer attention to standardization. In the report the various items relating to the design, construction and operation of mains were discussed briefly. Most of the data had been drawn from the letters, but other data had been received from outside sources. Items requiring research work, such as the design of high-pressure steam feeders and tests on automatic valves as they affect line capacity, were turned over to authoritative persons to insure accuracy in the results. In an appendix to the paper, descriptions were given of the underground insulations and conduits as they are placed upon the market by the various engineering and manufacturing companies.

BLEEDER TURBINES

Following an extended discussion on Mr. Woodworth's paper, F. W. Laas read a short paper on operating experiences with bleeder-type turbines. As a preliminary the author related an experience he had had with a 1500-kw. turbine of this type, also an experience with a cross-compound condensing engine supplying steam from the receiver for heating and eventually from the exhaust of the low-pressure cylinder against a maximum pressure of 25 lb. Mr. Laas enumerated the features a successful bleeder turbine should possess, some of the points to be watched in its operation and by means of data from specific cases explained the operating advantages of this type of turbine.

EDUCATIONAL COMMITTEE REPORT

At the afternoon session Wednesday, D. S. Boyden summarized the report of the educational committee. The work had been divided among the various members of the committee as follows: The establishment of a standard for transmission losses from buildings of all constructions, Reginald Pelham Bolton; the establishment of standard methods of proportioning direct radiation and standard sizes of steam and return mains, James A. Donnelly; the establishment of a standard coefficient for heat losses affected by wind movement, H. W. Whitten and R. C. March; the establishment of standard heating elements for cooking apparatus, with special reference to low-pressure steam, D. S. Boyden.

Mr. Bolton's contribution to the report brought out the wide variation in the hitherto accepted bases of computation. The various transmission losses through building materials were presented in tabulated form, with several suggestions for further observation, which may help to determine these losses definitely.

Mr. Donnelly's report was devoted mainly to the data required in estimating the heat requirements for buildings. It opened with tables of heat losses through building materials, including the losses through various thicknesses of concrete. These were followed by rules for estimating the amount of air required for ventilation. Under transmission from radiating surfaces a useful table was incorporated giving the relative surface in pipe coils and wall radiators. Another table showed the comparative transmission from a standard direct radiator at various steam temperatures. This was followed by a table giving the proportionate amount of radiation required to heat a room to 70 deg. F. from various outside temperatures, with steam in the radiator at 210 deg. F. A feature of many of the tables was that proportional requirements were given for conditions varying from the usual standard of 0 deg. outside and 70 deg. inside. Considerable space was devoted to the operation of gravity hot-water heating systems, vacuum-steam heating systems, forced hot-water heating systems and vacuum-vapor heating plants. In the section devoted to standard sizes of steam mains, a table of steam-pipe sizes based on the Unwin formula was included. Another table gave the comparative carrying capacity of pipes, so that after one size is figured for a certain condition, capacities of all other sizes may be readily obtained. At the conclusion of the report data were given on standard sizes of radiator connections and return mains, with a table showing the standard rating for steam mains as well as the standard for wet returns and for various percentages of steam carried in dry returns, figured for a drop in pressure of 1 oz. to 100 ft. of straight pipe.

A close study of the records of the Public Service Co. of northern Illinois for the past two years, in connection with other data referred to in last year's report, enabled the members of the committee having the work of determining the effect of wind on heating to obtain data from a large group of buildings of varied construction. The constant given last year was modified and now may be used safely, allowing for certain factors which may affect isolated cases.

The report by D. S. Boyden on standard heating elements for low-pressure cooking apparatus was one of progress only. Much remains to be done in this line. The report indicated, however, that apparatus in the kitchen and elsewhere that had formerly operated at pressures of 40 to 60 lb. will do the work satisfactorily on pressures as low as 3 lb. provided the heating elements are properly designed.

ELECTION OF OFFICERS

The commercial end of the heating business was discussed in a paper by C. F. Oehlman, and immediately after its presentation the election of officers took place, with the following results: D. S. Boyden, president; B. T. Gifford, first vice-president; George W. Martin, second vice-president; W. S. Monroe, third vice-president; D. L. Gaskill, secretary and treasurer; Thomas Donahue and C. F. Oehlman, members of the executive committee.

HOT-WATER HEATING

At the fifth session, Thursday morning, W. D. Carlton read his paper on "The Hot-Water Heating System at the Grand Central Terminal" in New York City. The paper was brief, giving in outline the arrangement and general construction, some of the operating features and capacities and the method of computing rates for the service.

REPORT OF STATION-OPERATING COMMITTEE

The report of the station-operating committee was then read by Byron T. Gifford, chairman. It included results of a boiler test conducted along lines suggested by last year's committee; statistics on operating costs, with tabulated results from a number of typical plants; the accounting of operating costs; general information regarding coal, with a table giving the designation, origin and analysis of a great variety of fuel; meters and their uses, including a description of the new Republic flow meter; and miscellaneous points of interest, such as the reason advanced by the New York Steam Co. for softening water that originally contained only 3½ grains of total solids per gallon.

EXHAUST VS. LIVE STEAM

At the last session of the convention, on Thursday afternoon, C. C. Wilcox read a paper comparing the use of exhaust and of live steam for heating. Tests were conducted on the heating systems of Peoria and Pekin, Ill. From a study of the tests, the following conclusions were derived: The heat consumption for the heating system under similar weather conditions was found to be the same for either live- or exhaust-steam operation; the rate of steam sent to the heating system is increased as the heat content of the steam is diminished; the carrying of an electric load in addition to the heating load cannot be accomplished without an increase in fuel; the main condensation with live steam is less than with exhaust steam; the pressure drop between the station and the end of line is more with exhaust than with live steam, which may be accounted for by the increased amount of steam delivered to the system; pulsations in pressure caused by the engine exhaust are not propagated very far from the source. A paper by George W. Martin on the same subject was read in abstract as a part of the discussion on the paper by Mr. Wilcox. Mr. Martin stated that it seemed to be the opinion of many engineers that in heating a building with exhaust or live steam a less quantity of the former was required. A number of instances were cited to show that this was not the case, provided the same temperatures were maintained in the rooms and equal attention given to obtaining economical results from the boilers. Investigations in several buildings had disclosed the fact that the bypass for admission of live steam into the heating system had been too small, so that enough steam could not pass through to the system. It gave the impression that the boilers were not large enough to supply the demand. By enlarging the bypass the difficulties were overcome, and the live steam gave as satisfactory service as the exhaust from the engines.

This concluded the papers, some of which will be abstracted more fully in these columns at a later date. Before adjournment the convention discussed the advisability of publishing a quarterly bulletin devoted to association affairs. A unanimous vote gave the board of directors power to act if the proposition was found feasible.

ENTERTAINMENT

Special entertainment for the ladies was provided in the way of a musical and card party, shopping excursions, automobile sightseeing rides, and a lake excursion on the United States training ship "Isle de la Luzon." On Tuesday evening a theater party was attended by all, and on Wednesday evening the banquet, followed by professional entertainment and dancing, was a great success. Fully 160 sat at table and all spent a most enjoyable evening.

EXHIBITS

The exhibits were more numerous than usual and presented an interesting variety of meters, pipe coverings, valves, steam traps and other equipment used in district heating. Following is a list of the firms represented: American District Steam Co., American Radiator Co., Armstrong Cork Co., V. D. Anderson Co., Boylston Steam Specialty Co., Cannelton Sewer Pipe Co., Central Station Steam Co., Consolidated Engineering Co., G. M. Davis Regulator Co., Detroit Lubricator Co., G. T. Hornung, Jenkins Bros., H. W. Johns-Manville Co., Michigan Pipe Co., National Air Cell Covering Co., Republic Flow Meters Co., E. D. Tyler, Westinghouse Electric & Manufacturing Co. and A. Wickoff & Sons Co.

Worcester Polytechnic Celebrates Fiftieth Anniversary

Fifty years of engineering instruction at the Worcester Polytechnic Institute was fittingly celebrated on June 8 and 9 by exercises preceding the annual commencement, this arrangement affording an opportunity for both undergraduates and alumni to attend and listen to the many prominent engineers and educators who participated.

Starting with a reception by President and Mrs. Hollis at the Bancroft on Tuesday evening, the principal exercises were held on Wednesday morning in Mechanics Hall, the speakers, besides President Hollis, including Governor Walsh of Massachusetts; Doctor Brashear, president of the American Society of Mechanical Engineers; President Lowell of Harvard; and Booker T. Washington, the well-known negro educator. On the platform with the speakers was a large number of delegates from engineering societies and colleges.

President Hollis, in his opening address, sounded a warning against carrying efficiency methods to extremes, claiming that "anyone can understand the application of good sense, good will and system in the mills and factories, but no American can approve any plan that lessens the responsibility of the individual by turning him into a machine."

Doctor Lowell was of the opinion that control over the forces of nature, as gradually worked out by the engineer, had more to do with human prgress, and especially the abolition of slavery, than any change in morals. He pointed out how, in the days of the Roman Empire, the ships were rowed by slaves, but as soon as other and better methods of propulsion were worked out through control of nature's forces, the necessity for these slaves ceased. He cautioned, however, against the misuse of engineering knowledge in lines that would be detrimental to humanity.

The Governor extended to the Institute the congratulations of the State, and was followed by Doctor Brashear, who in his characteristic humorous strain touched upon the human element in engineering work, emphasizing that education should not be for the good of the individual alone, but more particularly to enable one to better aid mankind. Doctor Washington told of the work being done in the negro trade schools with which he is connected in the South.

On Wednesday afternoon the local and visiting members of the American Society of Mechanical Engineers listened to a paper by Professor Alden on the history of the Washburn shops. These shops, in which the students of the Institute receive their practical training, consist of forge, foundry and machine shops and are carried along on a strictly commercial basis, the student working as an apprentice along with a paid journeyman.

In the evening a banquet was held at the Hotel Bancroft, about 600 attending. The speakers included Senator Weeks of Massachusetts; Major-General Wood; Howard Elliott, president of the New York, New Haven & Hartford R.R.; Arthur D. Little, of Boston; Mayor Wright of Worcester; and Francis W. Treadway, ex-lieutenant-governor of Ohio.

Water-Power Discussion at a Conference of Western Governors

The outstanding feature of the conference of Western governors held in Seattle during May was the discussion on legislation for the use of water power. Those who took part in the conference were the governors of Oregon, Washington, Idaho, Montana, Nevada, Arizona, Utah and Colorado. Governor Carlson, of Colorado, read a paper entitled "Unlocking the West."

That satisfactory results will follow the regulation of water-power sites by the Federal Government rather than the states was questioned by Governor Carlson. He did not favor the adoption of legislation by Congress along the lines of the Ferris bill, which provides that permits for the use of water power situated on government land shall be granted for fifty years, carrying the right of the Government to take over the property at the end of that time at a reasonable price for its physical value.

"We can't trust the state to manage water-power resources as well as we can trust the Government," Governor Boyle said in reply. "States are clamoring now to give away their resources, and while they may pretend to have the door closed, nevertheless their natural resources will be packed out of the windows."

"It is an outrage and shame the way our reasources in Oregon have been managed," said Governor West. "The plan of Secretary Lane for the leasing of water-power sites is a just one. The bill he proposes does not take away any of the sovereign rights of the states. They cannot be taken away by an act of Congress. What is a granted privilege today becomes a vested right tomorrow, and that is why the leasing system is best."

The argument was advanced that the royalty paid to the Government would be borne by the consumers of power and light, as it would be counted by the managers of the hydro-electric projects as a proper item of operating cost.

Governor Carlson outlined his position clearly and forcefully in his paper:

So long as the Department of the Interior revoked power permits only for misuse and nonuse, millions of dollars were put into power plants upon the public domain. The moment this principle was departed from, all development ceased. It is now proposed to remedy the situation by giving permits that will run for fifty years and carrying the right of the Government or the state or municipality to take over the property at the end of the term upon a basis of physical valuation. The plan also proposes to regulate the price of power and to divide the taxes assessed against the property between the Government and the state. For the sake of argument only, conceding the right of the Government to pass such a law, and supposing that it will pass, I do not believe any great development will follow. It is entirely unlikely that investors will put money into projects where no title passes; where the property might be subject to the onerous rules and regulations which thereafter might be promulgated; where there is possibility of conflict between the laws of the state and the rules of the Department of the Interior.

Investors are not likely to take kindly to a plan that would keep a property upon their hands if the venture be a losing one, or that might be taken from them if it proved a profitable one. The power of eminent domain inherent in every sovereign state has been used again and again when it has been found necessary to beneficially use the waters of a stream. Private property has always been subject to the exercise of this power by the state or delegated agents, and the only theory that would prevent its exercise by the states upon government lands is that such are not held by the Government in a private proprietary capacity, but as a superior sovereign power within a sovereign state. There is not a line in the Federal Constitution giving the Government a right to set up an independent sovereignty within the borders of a state, and I believe the time is not far distant when Congress will pass legislation declaring the inherent rights of Western states. Our greatest obstacle at the present time is to bring the East to our view. This is not as difficult as it was ten years ago. The multiplication of cases where millions of dollars of capital were planned to be expended in Western states for the development of its low-grade ores, of lighting plants, power plants, interurban lines, irrigation projects, etc., that have been diverted to Mexico, Bolivia and other foreign countries will strike home sooner or later to the Eastern manufacturer, and he will undergo the inevitable disillusionment of the enchanting theories of the ultra-conservationist.

"I think the policy of the Government holding title and leasing power sites to individuals, giving them only temporary control, is opposed to the best interests of the states," said former Governor Hawley, and he recited several cases that have gone to the highest courts of the land, upholding the sovereign power of the states in the management of their resources.

The conference, however, before its adjournment did not come to a definite agreement on legislation for the use of water power, as it was the sentiment to postpone action until the water-power conference to be held in Portland, Ore., Sept. 21-23, which the governors will attend. This question is also expected to be one of the leading features of the national conference of governors of the country to be held the last week in August, at Boston, Mass.

Rating of Diesel Engines

In the course of a lecture before the Junior Institution of Engineers, W. A. Tookey, the well-known English authority on internal-combustion engines, referred to the high rates asked for insurance against breakdowns of Diesel engines and to the occurrences reported from time to time in the technical press, in which broken crankshafts, seized pistons and similarly serious accidents are mentioned. These occurrences, he thought, proceeded mainly from the overstressing of cranks and the excessive heating of pistons, due to a prevalent tendency to over-rate the permissible output from given cylinder dimensions. He was inclined to lay the blame, not upon the technical men responsible for the details of construction, but upon those who are intrusted with the negotiations with prospective purchasers and who are particularly interested in claiming as small a ratio as possible between horsepower developed and initial cost. Cases had occurred in which lack of appreciation of this point had led to the engines working overloaded, or where it was found necessary to reduce the load originally contemplated, in order to avoid risk of breakdowns. Thus it had happened in a number of cases that the Diesel engine had not enjoyed the reputation that its high thermal efficiency and general reliability so amply merited when properly selected, erected and maintained.

Proceeding further to discuss this phase of the subject, the speaker pointed out that while the limit of power in an internal-combustion engine cylinder is definitely established and recognized, the rating of electrical machinery is purely arbitrary and apparently, therefore, much more elastic. Experience had dictated that a "rated" output about 10 per cent. below the permissible maximum, or overload rating of Diesel engines, is satisfactory and convenient. In smaller cylinders this could be based on a higher mean pressure than is advisable with cylinders of larger sizes.

He concluded with references to the manipulation of details in starting, running and stopping, and many valuable practical hints were given in this connection, both for single- and multi-cylinder engines. Particular emphasis was laid upon the paramount importance of scrupulous cleanliness and conscientious management, a matter which depends quite as much upon the personal attribute of the attendant as upon his technical ability.

OBITUARY

CLAUDE H. HUNTINGTON

Claude H. Huntington died May 21 after a brief illness. At the time of his death he was president of St. Louis Association No. 2, National Association of Stationary Engineers.

HARRY H. WHEELER

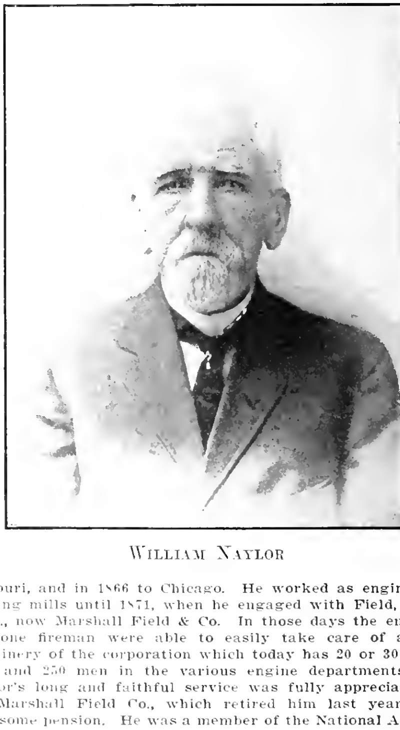
Harry H. Wheeler, of St. Louis, Mo., died suddenly on June 2, from injuries received in an automobile accident. He was a past-president of St. Louis Association, No. 2, N. A. S. E., and was a brother of William Wheeler, of New York, a Past-National President of the organization. About twenty-five years ago he left New York City to make his home in St. Louis. He is survived by a widow and three daughters.

JOHN F. FARLEY

John F. Farley, who died June 6 in Brooklyn, had for many years been employed as an engineer in the Department of Water Supply, Gas and Electricity of the City of New York, and for the last four years had been with the Department of Sewers. He was a member of the N. A. S. E. and the International Union of Steam Engineers.

WILLIAM NAYLOR

William Naylor died June 13 in Chicago at the age of 83. He was born in Lancashire, England, and seven years later began work operating hand machines in a calico-printing mill. He was apprenticed as machinist's assistant in the railroad shops at Bradford at the age of 9 and worked continuously until he retired last year. After serving several years as a locomotive driver on roads running between Yorkshire and Liverpool, he left England in the fall of 1858, and reached America by way of New Orleans, after a voyage of seven weeks on a combination steam and sailing vessel. He came by boat up the Mississippi and Ohio Rivers, and was employed as a sawmill operator and flour-mill engineer in Wabash County, Illinois. At the close of the Civil War he moved to



WILLIAM NAYLOR

Missouri, and in 1866 to Chicago. He worked as engineer in flouring mills until 1871, when he engaged with Field, Leiter & Co., now Marshall Field & Co. In those days the engineer and one fireman were able to easily take care of all the machinery of the corporation which today has 20 or 30 buildings and 250 men in the various engine departments. Mr. Naylor's long and faithful service was fully appreciated by the Marshall Field Co., which retired him last year on a handsome pension. He was a member of the National Association of Stationary Engineers since 1890, treasurer of the Robert Fulton Association continuously for 22 years, and was also a member of the Chicago Steam Engineers' Club. He was married to Ann Haigh before he left England and was the father of Charles William Naylor, Past National President, N. A. S. E. It was said that he was a friend of almost every operating steam engineer in and about the city of Chicago.

CHARLES E. CHINNOCK

Charles E. Chinnock, a manufacturer of telegraph instruments and one of the pioneers of the electric-light and telephone industries, died June 11 in Brooklyn, N. Y., in his seventieth year. When the telephone and electric light were still in their infancy he became associated with Thomas A. Edison, was later the superintendent of the first central station of the New York Edison Co., and as the vice-president of the Edison United Manufacturing Co., the parent Edison company, he was largely responsible for the founding of the Edison Electric Illuminating Co. of Brooklyn. The Edison United Manufacturing Co. was merged with the Thomson-Houston Co., which afterward became part of the General Electric Co. Mr. Chinnock was also chief electrician of the Metropolitan

Telephone Co., now the New York Telephone Co., and he patented many electrical inventions, among them an automatic transmitter, for teaching telegraphy that was adopted by the U. S. Government. Another of his inventions used by all the telephone and telegraph companies is a method of suspending aerial cables.

AUSTIN LORD BOWMAN

Austin Lord Bowman, one of the foremost bridge builders and engineers in this country, died June 3, at his home in New York City. He was born in Manchester, N. H., in 1861, and studied engineering at Yale, graduating in 1883. He engaged in engineering work continuously until the time of his death, specializing in design and heavy construction in both railroad and bridge work. Of his more important work, the construction of the Kings County Elevated Railroad in Brooklyn, his service as engineer in charge of construction for the American Bridge & Iron Co., and his reconstruction of the bridges on the Central Railroad of New Jersey are especially worthy of mention. He was made a member of the American Society of Mechanical Engineers in 1899 and was also a member of a number of other engineering societies. In 1907 he entered the service of New York City as consulting engineer of the Bridge Department, and in a few years was made chief engineer of the department, the position he held at his death. Commissioner Kracke, of the Bridge Department, and the chiefs of thirty departments under him, drew up suitable resolutions expressing their condolence, which will be embossed on parchment and presented to the family of their associate.

PERSONALS

S. H. Viall, assistant chief of the Chicago smoke department, has severed his connections with the city and is open for engagement.

Robert H. Kuss has severed his connections as sales engineer with the Edge Moor Iron Co. and will devote his time to advisory engineering.

J. A. Carson, better known as "Jack" Carson, formerly with the Durabla Manufacturing Co., is now connected with the Home Rubber Co., Trenton, N. J.

Hill & Ferguson, consulting engineers, 100 William St., New York City, have opened a laboratory for analyzing water and chemicals used in water treatment, as well as coal, oils and boiler compounds, and for testing the calorific value of coal.

S. F. Jeter has been appointed chief engineer of the Hartford Steam Boiler Inspection and Insurance Co. This is a recently created office, the holder to have general charge of the mechanical work for the company. Mr. Jeter for the past four years has held the position of supervising inspector in charge of the inspection service of the company.

ENGINEERING AFFAIRS

The Connecticut State Association of the N. A. S. E. will hold its annual convention at Hartford, on Friday and Saturday, June 25 and 26. The Engineers' Committee, assisted by the officers of the Supply Men's Association, has about completed the final arrangements, and a successful meeting is looked forward to.

The American Society of Refrigerating Engineers will hold its fourth Western meeting at San Francisco on Sept. 23 and 24. A special train, leaving Chicago Sept. 15 and arriving in San Francisco Sept. 21, has been arranged for the members, their families, and friends. Those attending the meeting will have the opportunity of attending the International Engineering Congress, which takes place from Sept. 20 to 25. Details of the trip may be obtained from the secretary of the association, W. H. Ross, 154 Nassau St., New York City.

The American Railway Master Mechanics' Association held its 48th annual convention, June 9-11, at Atlantic City, N. J. During the sessions committee reports were presented relating to locomotive stokers, smoke prevention, locomotive boilers, fuel economy and boiler washing. The Committee on Locomotive Stokers reported that the device was withstanding the test of continuous service with remarkable durability. Nothing novel has been presented during the past year, but a great deal of good work has been done in redesigning and improving detailed parts to better withstand the service. Data gathered from the scatter-type stokers in more extensive use show that the cost per 100 miles ranges from 43 to 68c., and the miles run per failure from 1000 to 5000. The committee felt unable to point to any rule in terms of weight of engine or train load, or to general conditions where the stoker will always be applicable or necessary. This is owing to the wide range in physical and operating conditions and in the character and price of fuel. According to the Committee on Smoke Prevention, continued use of the steam-air jets and quick-action blowers has further demonstrated that locomotives thus equipped may be kept comparatively free from smoke, provided the engine crews are properly instructed and carry out such instructions at all times. The report also presents a brief description of the Joint Smoke Inspection Bureau of the railroads operating in Chicago, and states that the record books of the City Smoke Department show a reduction in density of railroad smoke from 22% in 1910 to 7% in 1914. The committee on locomotive boilers recommended rules for determining stresses in such apparatus. These rules are the result of an analysis of existing practice of a number of representative railroads and locomotive builders. Since fuel economy depends not only upon the use of locomotives designed to have maximum efficiency, but to a large extent on their proper operation, the Committee on Fuel Economy presented a standard manual of instruction for enginemen and firemen. It is intended that this manual, while embodying all the essential points of efficient locomotive operation, should be brief and free from technical data. Superheaters, properly maintained and efficiently operated, are by far the most valuable mechanical aid to fuel economy ever applied to locomotives, and by their use savings of from 20 to 25 per cent. in coal and water are obtainable. The committee believed that to obtain the best results from the superheater a temperature indicator is desirable. The Committee on Boiler Washing gave an outline of the general practice of washing locomotive boilers. Many railroads have found that the use of hot water for boiler washing results in a saving of time, water and fuel. Chemical means of preventing incrustation are largely used. The chemicals are placed either in engine or wayside tanks, preferably the latter. The use of water-softening plants has resulted in an average increase in mileage between flue-setting and boiler repairs of over 100 per cent. In a paper on "Variable Exhaust," J. Snowden Bell stated that while these devices have effected an economy in fuel, none has proved sufficiently satisfactory or desirable, and it is not believed there are any at present in railroad service in the United States. In Europe, however, the early introduction of the variable exhaust has been followed by its general application. As an appliance designed to operate in the direction of economy of fuel, the variable exhaust merits careful consideration. If this be given, no doubt a variable exhaust can be produced to satisfy the requirements; that is to say, it would be properly constructed, automatically operable and fool-proof because independent of the human factor.

NEW PUBLICATIONS

DYNAMOMETERS. By F. J. Jervis-Smith and Charles V. Boys. D. Van Nostrand Co., New York. Cloth, 267 pages; 5½x9 in.; 119 illustrations. Price, $3.50.

DISTRICT HEATING. By S. Morgan Bushnell and Fred B. Orr. Heating and Ventilating Magazine Co., New York. Cloth, 290 pages; 6x9¼ in.; 82 illustrations; tables. Price, $3.

LOCATION OF CARBURETION TROUBLES MADE EASY. Chart arranged by Victor W. Page. Published by the Norman W. Henley Publishing Co., New York, 1915. Price 25c.

A plate showing a typical gasoline system as applied to an automobile motor, with a section through the carburetor. Motor troubles traceable to poor carburetion are diagnosed and the remedies prescribed; also general directions are included for the adjustment of carburetors. The automobilist will find the chart very useful.

HANDBOOK OF MACHINE SHOP MANAGEMENT. By John H. Van Deventer. Published by the McGraw-Hill Book Co., New York. Cloth, 374 pages; 4x6¾ in.; 244 illustrations. Price, $2.50.

This book is a careful effort to collect the best available information and data upon the details of management and to present them in concise form for the convenience of managers of machine shops and similar undertakings. To use the author's analogy, the book bears the same relation to those treating of systems of management that a book giving the fundamental data bears to books on the general theory of machine design. There is little that is speculative, and the information for the most part relates to data and elements of management that have been tested in actual practice. The book is arranged in handbook form, with seven sections. Under Section I are collected material and data on organization and system. Details pertaining to drafting-room systems, standardization of drawings and filing methods are given in Section II. The information in Section III relates mainly to the selection and installation of equipment, while Section IV contains data on shop and production orders and methods. Section V deals with timekeeping, payroll methods and cost-keeping. In Section VI are given data on shipping, transportation and tracing methods. In the last section information on safety mechanism, fire prevention and sanitation is given. While the beginner will find much of interest and profit in the book, because of the necessarily abbreviated treatment it will prove of more value to those who have already given some attention to these matters, and who can therefore use discrimination in selecting material.

EL INGENIERO Y CONTRATISTA

The title given applies to a new Spanish engineering periodical, the first number of which was issued in June. While the publication is begun in a small way, it is hoped to make it really useful in advancing the interests of American engineering practice in Spanish-America. It is published by Dodwell & Co., Ltd., 135 Front St., New York City.

TRADE CATALOGS

McNab & Harlin Mfg. Co., 55 John St., New York. Bulletin. Regrinding valves. Illustrated, 20 pp., 5x7 in.

Scranton Pump Co., Scranton, Penn. Bulletin No. 102. Duplex plunger pumps. Illustrated, 12 pp., 6x9 in.

Link-Belt Co., Philadelphia, Penn. Bulletin No. 221. Circular storage system for storing coal, etc. Illustrated, 4 pp., 6x9 in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 34-U. Instructions for installing and operating Class N-SP fuel oil driven compressors. Illustrated, 24 pp., 6x9 in.

Elliott Co., 6910 Susquehanna St., Pittsburgh, Penn. Bulletin L. Reducing valves. Illustrated, 8 pp., 6½x10 in. Bulletin M. Balanced valves. Illustrated, 4 pp., 6½x10 in. Gifford-Wood Co., Hudson, N. Y. Bulletin No. 17. Pivoted bucket carrier for conveying coal, ashes, etc. Illustrated, 16 pp., 6x9 in. Bulletin No. 18. Adjustable car loader for handling ice, house ice cutter. Illustrated, 8 pp., 6x8 in.

BUSINESS ITEMS

The Sullivan Machinery Co., Peoples Gas Building, Chicago, Ill., has moved its Boston office from 35 Federal St., to Room 1010, Unity Building, 185 Devonshire St.

The Kern Commercial Co., 114 Liberty St., New York, has received an inquiry from a client in Scandinavia for various steam specialties, such as lubricating apparatus and cups, injectors, valves, manometers, etc. The company is inviting figures.

The Terry Steam Turbine Co., Hartford, Conn., has appointed Joseph Battles as district sales manager for Denver, covering States of New Mexico, Colorado, Wyoming and the western portion of Nebraska. Mr. Battle's address is 326 First National Bank Building, Denver, Colo.

The McIntosh & Seymour Corporation, Auburn, New York, has appointed V. E. Raggio, 1107 Nevada St., El Paso, Texas, to represent the company in Arizona, New Mexico, Texas west of a line drawn north and south through Del Rio, and the States of Sinaloa, Sonora, Chihuahua, and Durango, in Old Mexico.

The Ingersoll Rand Co., 11 Broadway, New York, has recently issued a catalog, form 3031, descriptive of the new "Ingersoll-Rogler" Class "FR-1" Steam Driven Single Stage Straight Line Air Compressors. The catalog is profusely illustrated showing the details of the machine in section and is sent on application.

Ice Making Plants in the U. S.—We are advised by the editor of "Ice and Refrigeration" that the number of ice-making plants in the United States is not 12,500, as given on page 659 of our May 11 issue, but 4245, as given in the "Ice and Refrigeration Blue Book."

The World Bestows Big Prizes, both in money and honors, but for one thing. And that is initiative. Initiative is doing the right thing without being told; but next to doing the thing without being told is to do it when you are told once. Next, there are those who never do a thing until they are told twice; such get no honors and small pay. Next, there are those who do the right thing only when necessity kicks them from behind, and these get indifference instead of honors, and a pittance for pay.—Elbert Hubbard.

NEW EQUIPMENT

ATLANTIC COAST STATES

It is reported that the Athol Gas & Electric Co., Athol, Mass., contemplates extending its transmission lines to Petersham, Mass., if sufficient business is guaranteed. The estimated cost of building the line and installing the distribution system is from $10,000 to $15,000. George MacKnight, Athol, is Supt. and Ch. Engr.

The City Council of West Newbury, Mass., is considering the installation of a municipal electric-lighting system. The present service is furnished by the Newburyport Gas & Electric Co.

It is reported that the City Council of Lindenhurst, N. Y., is considering the installation of an electric-light plant in connection with the municipal water-works system.

The Diamond Match Co., Oswego, N. Y., has awarded the contract for the construction of its new power house in Oswego. The equipment will include two 500-hp. boilers (with space for a third one of the same size) and two 1000-kw. generators. The boilers will be equipped with automatic stokers.

SOUTHERN STATES

It is reported that contracts will soon be awarded by the Town Council of Dayton, Va., for the installation of a municipal electric-light plant. Bonds to the amount of $24,500 were recently sold for this purpose and the construction of a sewer system.

The People's Light, Heat & Power Corporation, Westpoint, Va., contemplates the construction of an addition to its plant and the installation of another unit. Samuel MacWatters is Supt.

The City of Hertford, N. C., is considering a bond issue of $12,000, the proceeds of which will be used for the installation of a municipal electric-light plant.

The City of Warsaw, N. C. has granted a franchise to Oliver Pettit, Clinton, N. C., for the installation and operation of an electric-light plant.

Plans are being prepared for the construction of a municipal electric-light plant at Ocala, Fla., estimated to cost $75,-000. H. C. Sistrunk is City Clk. Twombly & Henney, 55 Liberty St., New York, N. Y., is Engr.

The City of White Castle, La., will install a municipal electric-light plant to cost about $25,000. Xavier A. Kramer, Magnolia, Miss., is Engr.

It is reported that E. B. Jones and John E. Green are interested in the establishment of an electric-light plant at Crossville, Tenn

It is reported that E. H. Crump, Mayor of Memphis, Tenn., is agitating a project to build or buy a municipal electric-light plant. A bond issue of $1,500,000 is said to be available for the purpose.

The Commercial Club of Harlan, Ky., is reported to be promoting the establishment of a $250,000 electric plant in Harlan, to be built by an association of Cincinnati capitalists.

CENTRAL STATES

It is reported that the Canton Electric Co., Canton, Ohio, has purchased a site for the construction of an addition to its power station. The company has authorized improvements to its system to cost about $250,000. W. C. Anderson, Canton, is Mgr. and Supt.

The Board of Education of Cincinnati, Ohio, Charles Handman, Business Mgr., has engaged an engineer to prepare plans and estimates of the cost of installing electric generating stations in a number of the larger school buildings of the city.

A special election will be held June 22 at Painesville, Ohio, to vote on the question of issuing $35,000 in bonds for the purpose of improving the municipal electric-light plant.

The Ohio Light & Power Co., Tiffin, Ohio, has made application to the City Council of Granville, Ohio, for a franchise to supply electricity for domestic and commercial purposes in the latter place.

C. C. Outland, Mayor of Zanesfield, Ohio, and E. Huntzinger, Piqua, are preparing to organize a company to install and operate an electric-light plant in Zanesfield.

It is reported that the Mohawk Mining Co., Calumet, Mich., plans to install an electric-light and power plant.

WEST OF THE MISSISSIPPI

According to press reports, bids will soon be asked for the installation of a municipal electric-light plant in Davenport, Neb. Charles F. Sturtevant, Holdredge, Neb., is Consult. Engr.

At a recent special election in Tekamah, Neb., the citizens voted to issue $15,000 in bonds to be used for extending the municipal electric-light plant to furnish 24-hr. service. M. S. McGrew is Secy. and Cont. Agt. of the plant.

It is reported that arrangements are being made for the installation of an electric-light plant in Michigan, N. D.

The Town of Chilhowee, Mo., has voted a bond issue of $6800 to be used for the installation of a municipal electric-light plant.

It is reported that W. B Rollins & Co., Midland Bldg., Kansas City, Mo., is preparing preliminary plans for the installation of a municipal electric-light plant at Harrisonville, Mo. The estimated cost is $15,000.

It is reported that the Sterling Consolidated Electric Co., Sterling, Colo., will shortly install a 250-kw., three-phase, 60-cycle, 2200-volt generator and engine. The company will purchase stokers for three boilers, poles and wire. H. L. Titus is Mgr.

POWER

Vol. 41 NEW YORK, JUNE 29, 1915 No. 26

That Peak Load Problem

By Berton Braley

WE'VE rustled for power contracts and landed a lot as well,
We've hunted the country over for fancy outfits to sell,
We've peddled electric irons, we've boosted electric pots,
And gathered up fans and sold 'em in regular carload lots,
We've hinted and preached and threatened and advertised year on year
And talked to the folks like Uncles and written 'em plain and clear,
But in spite of our ceaseless efforts, our labors almost sublime
Full half of our power units are idle most of the time.

And that's the fault of peak load
(It never is a weak load)
Which jumps upon the backs of us at certain times of day
A bold and not a meek load,
A make-you-swear-a-streak load,
Oh, if it weren't for peak load our labor would be play.

THE sun goes down in the western sky and the stars come into sight,
And the homes of the busy city are drawing on us for light,
The theaters glow in glory, the signs and the street lights glare,
And here at the central station we've worry enough to spare,
For the straining boilers tremble, the laboring engines throb
And we start up the whole equipment to handle the heavy job,
It's trouble enough on week days to manage the problem well
And then when Saturday Night comes round—say, SATURDAY night is Hell!

And so we cuss the peak load
The big load, the freak load,
Which jumps upon the backs of us at certain times of day,
A strong and not a weak load
A make-you-swear-a-streak load,
Oh, if it weren't for peak load our labor would be play.

IF only the load were steady each hour of the twenty-four
We wouldn't be fretting and fuming and figuring any more
On boosting the "off hour" business by every kind of scheme;
But the peak load still is with us and life is no idle dream.
For all of the new inventions we've brought to the public's view
Electric curling irons and vacuum cleaners, too,
For all of our advertising, our urging in prose and rhyme,
Full half of our power units are idle most of the time.

And that's the fault of peak load
(It never is a weak load)
Which jumps upon the backs of us at certain times of day,
A not at all unique load
Yet, in a way, a freak load
Oh, if it weren't for peak load our labor would be play.

Washington Avenue Power Plant, Scranton, Penn.

By Warren O. Rogers

SYNOPSIS—This plant has been remodeled at a cost of $2,000,000. Six new water-tube boilers, each with 5580 sq.ft. of heating surface, have been installed. The generating units consist of three turbo-generators and two reciprocating engine-driven units, the latter exhausting to a district heating system during cold weather. Culm fuel having an average calorific value of 10,500 B.t.u. is burned in the boiler furnaces. This fuel has been through the washery twice and contains approximately 5.02 per cent. volatile matter, 74.98 per cent. fixed carbon and 20 per cent. noncombustible matter. At 163 per cent. of boiler rating 6.07 lb. of water is evaporated from and at 212 deg. in the old boiler plant. A test of one of the new boilers gives an evaporation of 8.38 lb. of water from and at 212 deg.

The City of Scranton, Penn., is situated in the heart of the Lackawanna Valley, one of the greatest anthracite producing regions in the country. The mines are dotted here and there all along the valley and range in size from those requiring 50 or 100 hp. in their operation up to those requiring from 2000 to 3000 hp. Many, in fact most, of these mines still use steam power and their electrification is for the future.

Naturally, in this region the greatest competitor of a central station is cheap coal, and in order to obtain and keep its business it must be in a position to sell electrical energy at an attractive rate and to give reliable service.

When the American Gas & Electric Co. took over the Scranton properties eight years ago, there were six companies supplying electric service from four generating stations to consumers, the combined yearly output of these plants being about 11,000,000 kw.-hr. Today the yearly output of the company generated in its two stations is more than 60,000,000 kw.-hr., which is distributed over 70 square miles, furnishing current to 16 cities and boroughs, ranging from 200 to 130,000 in population.

The old properties were becoming obsolete, and to meet the increasing business both for the present and for the

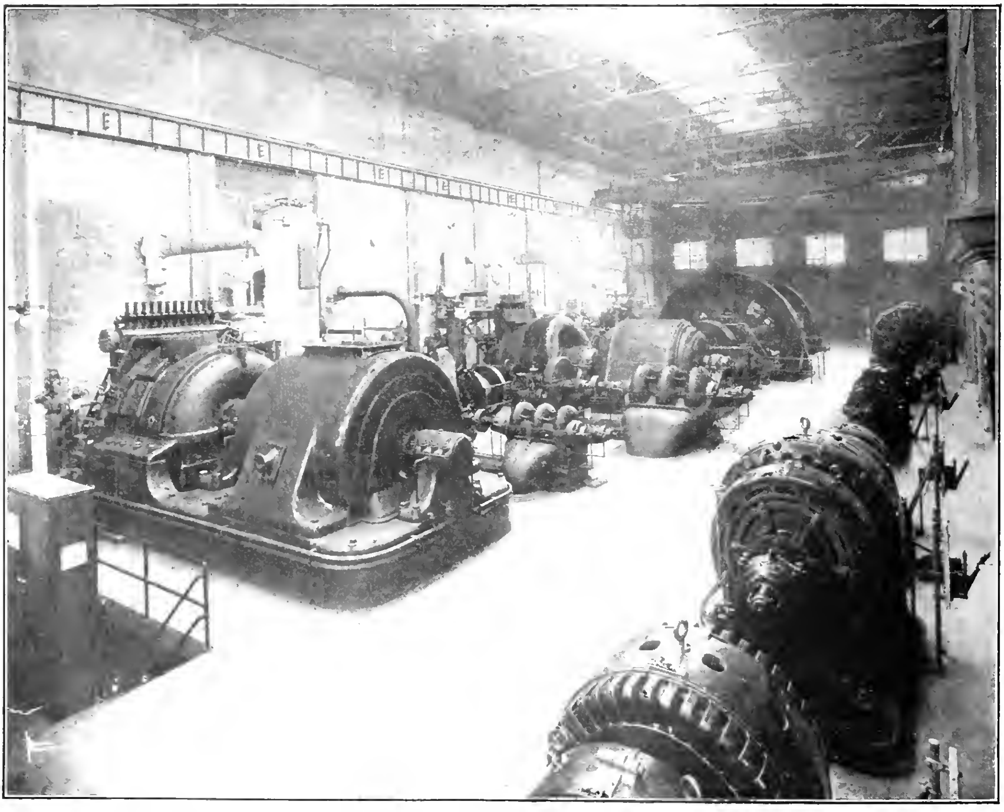


Fig. 1. General View of the New Washington Avenue Power Plant, Scranton, Penn.

future the suburban power plant on Washington Ave. has been rebuilt with the exception of the old boiler room. The new power house is 200 ft. long, 64 ft. wide and 37 ft. high to the steel roof trusses. The basement is 14 ft. 6 in. deep and contains the condensing apparatus. A new fireproof boiler house 120 ft. long, 115 ft. wide and 40 ft. high to the roof trusses, forms an ell with the old building.

The plant, before being remodeled, contained three 300-kw. alternating-current generators, two being belt-driven from two engines, from which alternating current was secured, and one was motor driven. These units were run separately with a total load of 1200 kw. The old station, with its belt-driven units, was typical of the old-time plant.

New Turbine Room

A view of the present turbine room is shown in Fig. 1, two of the three units being in the foreground. There are two Curtis-Rateau 10,000-kv.-a. horizontal turbo-generators and one 4500-kv.-a. unit, both generating current at 4000 volts. Two of the original 3500-hp. engines are retained. One, a cross-compound with cylinders 36&66x48 in., is directly connected to a 4000-volt, 2000-kv.-a. three-phase, 60-cycle alternator, and runs at 100 r.p.m. This engine is arranged to run condensing, to the atmosphere, or to exhaust into a heating system working against an average back pressure of 8 lb. The other reciprocating unit is a twin engine with cylinders 36x48 in., and runs at 100 r.p.m. It is directly connected to an alternator of the same size as that of the compound unit. This engine, which has been in service about four years, is designed to operate against a 40-lb. back pressure, as that was the pressure carried on the commercial heating system at the time it was installed. The weight of each flywheel is 65 tons.

The compound engine is piped to a surface condenser containing 6000 sq.ft. of cooling surface, or 1.7 sq.ft. per hp. The volute circulating and the hotwell pumps in the basement are turbine-driven. The 8x20x12-in. air pump is on the main floor. The condensers for the turbines are connected by expansion joints. The 10,000-kv.-a. turbine condenser has 20,000 sq.ft. of cooling surface, or 2.66 sq.ft. per kw. The condenser for the latest 10,000-kw. turbine installed is of the usual design, but it has a special arrangement of the tubes. It contains 30,000 sq.ft. of cooling surface, or 3 sq.ft. per kw. of turbine capacity. That for the 1500-kv.-a. unit has 11,000 sq.ft. of cooling surface, or 2.7 sq.ft. per kw.

The 20- and the 28-in. triplex volute circulating pumps for both condensers are turbine driven, and are on the main floor, as are also the 12x30x16-in. and the 8x20x12-in. dry-air pumps for the 10,000- and the 1500-kv.-a. units. A vacuum within 2 in. of the barometer is maintained with injection water at 70 deg., and within 3 in. at 80 deg. F.

Circulating water flows to the pumps by gravity from eight cooling towers at the rear of the plant and 50 ft. above the basement floor. The return water is through a 42-in. diameter cast-iron pipe, and is controlled by motor-driven valves.

Cooling Towers

The cooling towers, Fig. 2, are of the combination fan and natural-draft type. They are built over a covered concrete reservoir with concrete columns extending above the reservoir on which the towers rest, and leaving openings between the columns for the entrance of air when the towers are operated on the stack-draft principle. The air spaces below the towers are separated by concrete aprons extending from the under side of the top of the reservoir down to a point below the water level, thus making each tower independent of the others, so far as operation is concerned. The stacks are built of sheet steel riveted and are cylindrical in form, the lower parts being 24 ft. in diameter and the towers 70 ft. high from the top of these supporting piers.

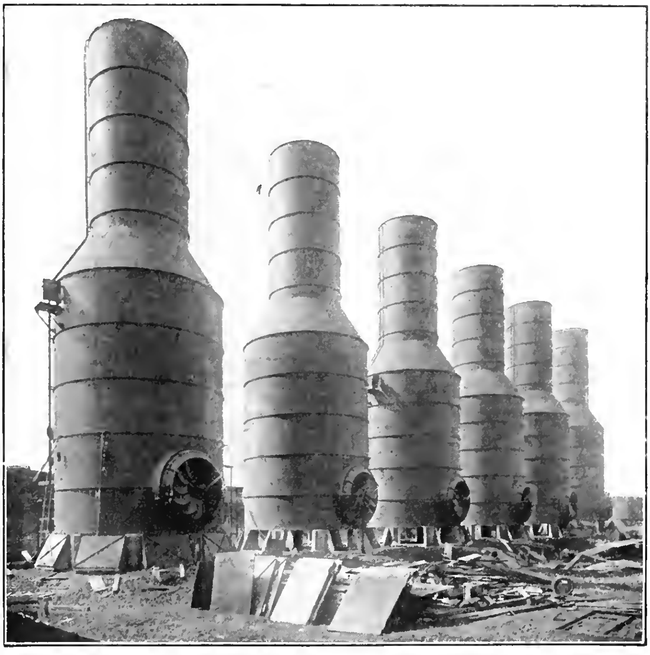


Fig. 2. Combined Fan and Natural-Draft Cooling Towers

Each tower is provided with two 10-ft. diameter fans mounted on one shaft and driven by a motor in a concrete housing close to the tower. The cooling surface consists of dressed cypress boards set on edge, each course being arranged at right angles to the course below.

Warm circulating water is brought to each tower through a 14-in. discharge pipe entering at a point just above the fans and extending up through the center of the tower to a point just over the cooling surface. On the top of this discharge pipe is a self-rotating water distributor, which is revolved by the reaction of the jets of circulating water and rotates on a lignum-vitæ bearing which, being lubricated by a part of the circulating water, requires no attention.

The special openings between the supporting piers at the base of the tower are provided with steel doors hinged

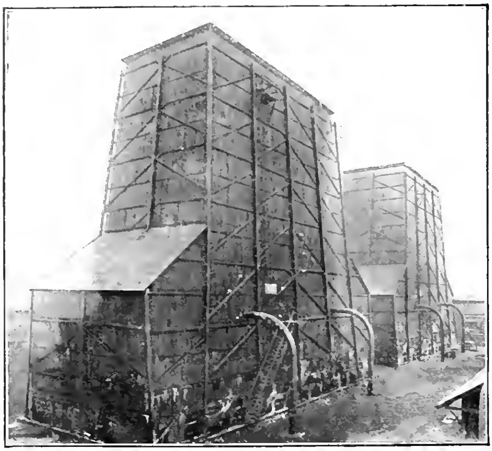


FIG. 3. TWO COOLING TOWERS, CAPACITY 5000 GAL. PER MIN.

at the top and partly counterweighted with chain and weight to facilitate opening and closing. The lower part of the tower can be entered through one of these draft doors, and the distributor and upper part of the cooling surface are accessible through a door arranged at the side of the stack. A ladder extends from the ground to the top of the tower, passing close to the platform in front of the upper opening.

This battery of towers is capable of cooling the circulating water from the condensers serving a power plant of 14,500 kw., when maintaining a vacuum within 3 in. of the barometer, and during summer weather conditions with forced draft.

In cold weather, or when the load on the power station is light, the fans are stopped, the draft doors are opened and the towers allowed to operate on a stack-draft principle, thus saving the power necessary to operate the fans.

There are also two natural-draft cooling towers working in connection with a 10,000-kw. turbine. These towers are shown in Fig. 3. They are about 250 ft. long, and 100 ft. high, and are of the all-wood natural draft type, built under a license from the Balcke Co. of Germany. So far as known, these are the largest natural-draft cooling towers installed in the United States.

The condensate and circulating pumps are mounted on a single bedplate and driven by a steam turbine through a common shaft. Fig. 4 shows the unit in part. The pump *A* is a combined hydraulic-air and condensate pump. There is but one connection to the condenser—the condensate and non-condensible vapors being separated in this pump. In case the hurling water used in the air pump becomes too hot it can be cooled by city water.

The centrifugal circulating pump *B* is of standard type. An interesting fact concerning this installation, as shown by the readings for a day herewith given, is that the vacuum is better than 29 in. practically throughout. It is understood that this showing is a record in this country, and there are no data available from foreign plants showing such results. The readings are as follows:

SCRANTON ELECTRIC COMPANY Feb. 25, 1915

Time	Load, Kw.	Circ. Inlet	Circ. Outlet	Condensate	Temp. Atmos.	Humidity	Corrected Vacuum	Hurling Inlet	Water Outlet	Cooler In	Cooler Out	Speed Pump
12:	3400	55	63	60	38		29 24	50	51	38	50	1500
1:	2600	53	59	57	36		29 25	48	48	38	48	1500
2.	2000	51	56	53	36		28 25	46	47	38	47	1500
3.	800	49	52	51	36	.	29 44	46	47	30	47	1500
4:	800	46	48	47	36	..	29 48	45	46	off		1500
5:	800	44	45	45	34	..	29 48	47	47	off		
6:	3200	46	53	48	32	.	29 48	49	50	38	50	
7:	3800	50	58	58	32		29.25	47	48	38	50	
8:	4000	52	61	57	35	70	29 3	50	51	38	50	
9:	5600	55	64	61	32	70	29 24	54	56	38	53	
10:	4800	55	65	62	34	70	29 24	58	58	38	57	
11:	4800	56	66	63	34	70	29 29	55	56	38	56	
12:	5600	57	62	64	36	70	29 20	55	56	38	55	
1	6000	56	66	63	36	70	29 24	53	54	39	53	
2:	5400	57	67	64	36	..	29 19	58	59	38	57	
3:	5400	57	67	67	35	..	29 19	58	59	38	50	
4:	6000	59	70	68	35	..	27 14	53	55	38	48	
5:	6000	58	69	67	35	70	29 19	50	52	38	48	
6:	5200	57	68	65	32	.	29 20	48	50	38	47	
7:	8000	59	78	70	30	..	29 1	51	53	39	49	
8:	8000	59	75	72	30	..	29.05	52	55	39	49	

The combined condensate and turbo air pump* is driven by the same auxiliary turbine that drives the circulating pump. This arrangement is compact and requires less attention than the general arrangement of condensing apparatus. The exhaust steam from the pump turbine is connected to the second stage of the 10,000-kw. turbine. The exhaust pipe from the pump turbine is fitted with an automatic trip throttling valve close to the connection to the large turbine. There is also a back pressure valve set at 15 lb. pressure absolute. The pressure in the first stage of the turbine is 30 lb. and that of the second stage is 13 lb. absolute, therefore the exhaust steam enters the second stage of the large turbine at a pressure of 2 lb. above that existing in that

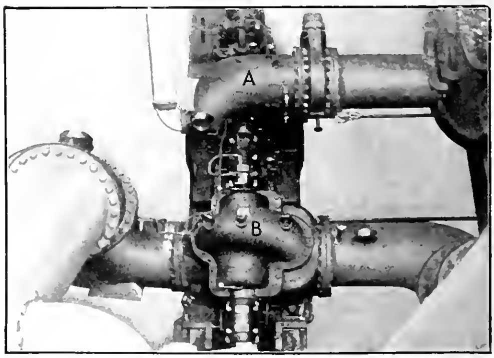


FIG. 4. TURBO-AIR AND CONDENSATE PUMP ON SHAFT WITH CIRCULATING PUMP

portion of the turbine. In the near future the exhaust steam from the other turbine auxiliaries will be connected to their respective turbines and the exhaust steam used in the second stage.

The makeup water is taken from the city water mains. The feed water is taken from one 4000-hp. open

*Details of a test of one of these air pumps were published on page 442 of the Mar. 30, 1915, issue.

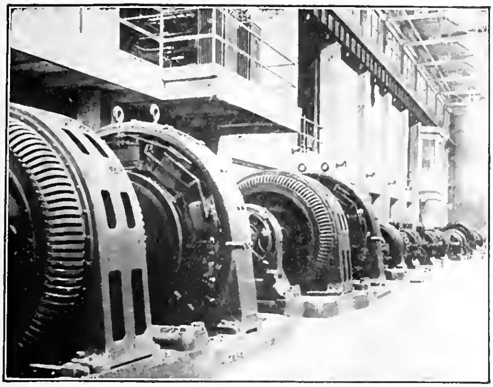


FIG. 5. A LONG LINE OF MOTOR-DRIVEN UNITS

heater by two 16x10x18-in. outside-packed pumps controlled by a pump governor and from one 5000-hp. heater by two 500-gal. capacity centrifugal boiler feed pumps. Exhaust steam from the auxiliaries is used for heating the feed water, all, with two exceptions, exhausting into a common header. The circulating pumps on the 10,000-kv.-a. turbine units are arranged to run either condensing or noncondensing, assuming that with both main turbines in operation more than enough exhaust steam would be obtained for feed-water heating.

AUXILIARIES

Along the switchboard side of the turbine room is a row of motor-driven units, shown in Fig. 5, consisting of the following:

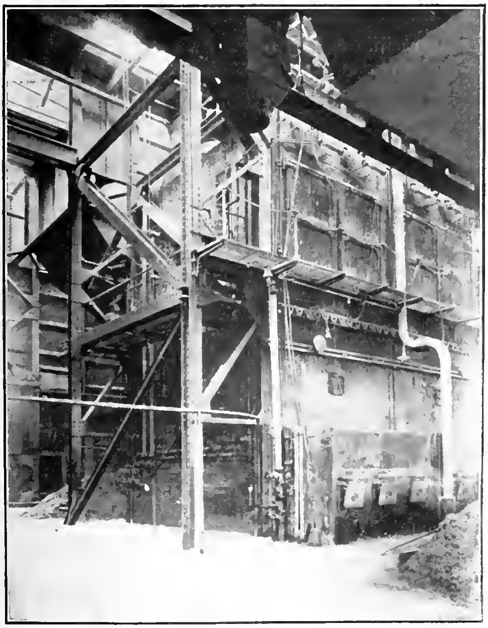


FIG. 6. ONE OF THE NEW DOUBLE-DECK BOILERS

Two 1400-hp. synchronous motors directly connected to two 1000-kw., 550-volt railway generators, speed 514 r.p.m. These units have a 125-volt exciter mounted at one end of each shaft.

Two 250-hp., 4000-volt synchronous motors, each directly driving three 6.6-amp. arc-light machines at 514 r.p.m.

One 186-hp., 4000-volt synchronous motor directly connected to two 6.6-amp. arc-light machines at 514 r.p.m. motor circuits.

One 150-hp. induction motor driving 100-kw., 250-volt, direct-current generator at 580 r.p.m.

One 300-hp. induction motor driving a 200-kw., 250-volt, direct-current generator at 580 r.p.m.

There are three exciter units: One is a 150-kw., turbine-driven set generating 125-volt direct current at 3775 r.p.m.; one is an induction, 250-hp. motor-generator set generating 125 volts at 720 r.p.m.; and the third is a 10&18x10-in. marine engine directly coupled to a 150-kw., 125-volt, direct-current generator, at 340 r.p.m.

BOILER ROOM

The old boiler room contains only water-tube boilers, of which four are of 180-hp. capacity, four 600-hp., and

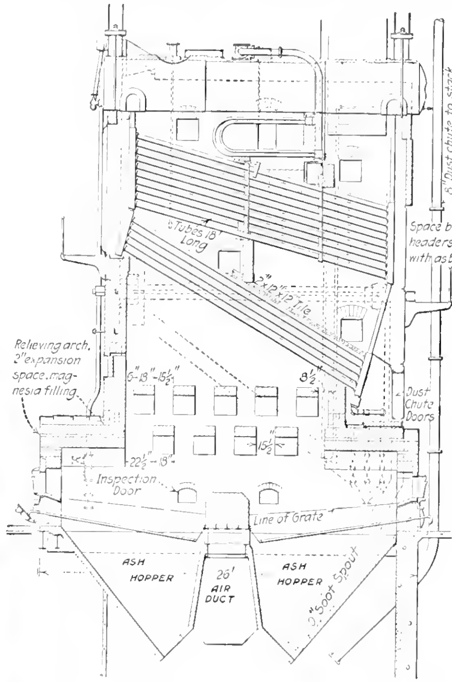


FIG. 7. SECTION THROUGH ONE OF THE BOILERS

five 300-hp. The eight largest are equipped with dutch-oven furnaces and dumping grates. The five small ones have shaking grates. All are equipped with regulators, and but two have superheaters.

In the new room, Fig. 6, there are six special-type, double-deck, water-tube boilers with two banks of 18-19-ft. tubes, each 18 sections wide; the upper one is 10 and the lower 5 tubes high. These boilers are double-end and are at present hand fired. Mechanical stokers are to be installed in the near future capable of handling the grade of fuel now being burned. Each boiler contains 5580 sq.ft. of heating surface and is rated at 558 hp. The grate surface is 217 sq.ft., which gives 2.57 sq.ft. of heating surface per square foot of grate surface. Washed buckwheat and anthracite culm are used.

Fig. 7 is a section through one of the new boilers. Forced draft is used, the main air duct being between the ash hoppers and opening to a blast box which is equipped with hand-operated dampers for controlling the volume of air admitted below the grates. The staggered arches are 18 in. wide and spaced 15½ in. This arrangement is to provide a baffling which, with its high temperature, will cause the furnace gases to burn before striking the comparatively cool tube surface; also, to diffuse the heat currents so that they will reach the heating surface of the lower bank of tubes from end to end.

This method of arch construction has developed trouble in that the arches have been found difficult to keep in place. To preserve them in place a pillar 2x4 ft. in size has been built between the bridgewall and an arch 11 ft. long, 9 ft. high and 6 ft. cross-section, and arched 15 in. at the center. This arch replaces the bottom one, Fig. 7, and the brick column has proved satisfactory. The six new boiler furnaces will be so equipped.

Resting on the top row of the lower bank of tubes is a tile baffle wall, which extends 10 ft. 9 in. from the lower end of the tubes. The upper bank is baffled for three passes of the gases, the superheater being placed between the first and second pass.

In order to facilitate cleaning the space between the two banks of tubes, provision has been made to remove the dust to the ash hopper through a 10-in. dust chute. Dust from the stack is taken care of by an 8-in. chute which is brought down to a point convenient for discharging into a tile drain running to the ash accumulating pit.

Following are the results of tests recently run on two of these boilers:

BOILER TESTS AT THE WASHINGTON AVENUE PLANT

Boiler: Babcock & Wilcox W. S. V. II. Special. 18 Sections, 10 High, 18-ft. Tubes. 18 Sections, 5 High, 19-ft. Tubes. Two 42-in. Drums—5580 sq. ft. H. S.-Rating 558 hp. Babcock & Wilcox Superheater. Furnace Double End. Hand-fired. 217 sq.ft. G.S.
Coal: Washed Buckwheat No. 2—Slush—Bituminous—"Shawmut."

Date...		Aug. 19, 1914	Aug. 21, 1914	Aug. 24, 1914	Aug. 25, 1914	Aug. 27, 1914	Aug. [illegible] 1914
Duration	Hr.	8.07	8.00	8.17	8.00	8.00	8.00
Kind of coal....		Washed	Slush	10% soft—90% slush	70% washed—30% slush	10% soft—90% washed	Washed
Steam pressure..	Lb.-Sq In	156.00	155.00	154.00	157.00	158.00	158.00
Temperature superheated steam	Deg F.	437.20	439.90	445.70	445.00	441.60	437.80
Degrees superheat	Deg F.	68.30	71.40	77.70	75.60	71.70	67.90
Temperature feed ...	Deg F.	64.00	65.50	65.00	65.30	65.00	65.00
Factor of evaporation...		1.2408	1.2408	1.2447	1.2437	1.2420	1.2399
Total water..	Lb	237,523	173,634	214,563	226,173	306,720	285,960
Total water from and at 212 deg	Lb.	294,719	215,445	267,067	281,291	380,946	354,618
Water per hour from and at 212 deg	Lb.	36,520	26,931	32,689	35,161	47,618	44,320
Total coal fired....	Lb.	41,793	45,600	48,400	51,960	50,400	48,800
Per cent. moisture.	Per Cent.	9.50	16.35	16.47	12.79	8.49	7.56
Total dry coal.....	Lb.	37,823	38,122	40,429	45,314	46,121	45,111
Total ash and refuse as weighed	Lb.	11,351	14,941	13,092	17,039	12,089	12,066
Moisture in ash and refuse ...	Per Cent.	1.24	0.12	2.86	0.24	0.66	0.20
Total dry ash and refuse as weighed	Lb.	11,210	14,923	12,729	16,998	12,009	12,042
Ash and cinder from roof	Lb.	128	406	501	549	500	494
Total ash and cinder figured from coal and ash analyses...	Lb.	280	1,377	1,540	1,602	665	1,035
Total dry ash and refuse	Lb	11,490	16,300	14,269	18,600	12,674	13,077
Total combustible...	Lb.	26,333	21,822	26,160	26,714	33,447	32,034
Per cent. of ash from test...	Per Cent.	30.38	42.76	35.29	56.74	27.48	28.98
Draft at damper.....	In. of H_2O	0.43	0.53	0.50	0.52	0.55	0.49
Draft bottom first pass..	In. of H_2O	0.04	0.06	+0.01	+0.01	+0.03	+0.01
Draft in furnace, front....	In. of H_2O	0.14	0.12	0.08	0.06	—0.02	—0.06
Draft in furnace, rear ...	In. of H_2O	0.15	0.12	0.09	0.09	—0.02	0.07
Pressure in ash pit, front.	In. of H_2O	1.46	2.09	1.88	2.68	1.83	1.74
Pressure in ash pit, rear.....	In. of H_2O	1.41	1.81	1.87	2.46	1.82	1.65
Temperature flue gases..	Deg. F.	513	485	511	520	544	535
Temperature room....	Deg. F.	91	84	84	80	82	80
Coal per sq.ft. g.s. per hour as fired	Lb.	23.98	26.39	27.43	30.07	29.17	28.24
Coal per sq.ft. g.s. per hour, dry	Lb.	21.70	22.06	22.91	26.22	26.69	26.11
Water from and at 212 deg. per hour per sq.ft. h.s. .	Lb.	6.50	4.80	5.90	6.30	8.50	7.90
Actual evaporation per lb. of coal as fired	Lb.	5.68	3.81	4.43	4.35	6.09	5.86
Equivalent evaporation from and at 212 deg. per lb. dry coal.........	Lb.	7.79	5.65	6.61	6.21	8.26	7.86
Equivalent evaporation from and at 212 deg. per lb. of combustible.......	Lb.	11.19	9.87	10.21	10.53	11.39	11.07
Horsepower developed...		1058.50	780.6	947.50	1019.10	1380.20	1284.60
Per cent. rating.......	Per Cent.	189.70	139.90	169.80	182.60	247.30	230.20
Efficiency dry coal basis .	Per Cent.	65.54	52.57	61.56	57.71	66.61	64.79
Efficiency combustible basis .	Per Cent.	76.19	67.48	70.27	71.99	76.07	74.59
Gas analysis CO_2	Per Cent. Vol.	12.00	9.10	10.20	9.70	13.20	13.00
O_2	Per Cent. Vol.	7.50	10.70	9.40	9.40	6.40	6.70
CO .	Per Cent. Vol.	0.00	0.00	0.00	0.00	Trace	Trace
N_2	Per Cent. Vol.	80.50	80.20	80.40	80.90	80.40	80.30
Coal analysis moisture	Per Cent.	9.50	16.35	16.47	12.79	8.49	7.56
Volatile matter.	Per Cent.	8.98	9.60	11.87	9.34	10.05	9.44
Fixed carbon ..	Per Cent.	71.94	63.88	62.03	64.22	72.77	72.30
Ash.....	Per Cent.	19.08	26.52	26.10	26.44	17.18	18.26
B.t.u. dry coal		11,533	10,430	10,420	10,441	12,034	11,772
B.t.u. combustible..		14,252	14,194	14,100	14,194	14,530	14,401
Ash analysis moisture	Per Cent.	1.24	0.12	2.86	0.24	0.66	0.20
Volatile matter ..	Per Cent.	1.96	2.56	2.00	1.24	1.12	2.64
Fixed carbon.	Per Cent.	36.16	38.92	27.20	37.70	38.44	39.06
Ash.... ...	Per Cent.	61.88	58.52	70.80	61.06	60.44	58.30

The capacities secured in the tests are interesting in view of the poor quality of coal used, and this is also true of the efficiencies. Heat balances which have been worked out from three of these tests show the following results:

	Date		
	Aug. 19	Aug. 21	Aug. 28
Heat absorbed by boiler...........	65.54	52.57	64.79
Loss due to moisture in coal........	1.02	1.92	0.80
Loss due to burning hydrogen	2.35	2.71	2.34
Loss due to chimney gases	11.31	11.71	10.91
Loss due to moisture in air.........	0.54	0.33	0.46
Loss due to incomplete combustion.	0	0	0
Loss due to carbon in ash..........	14.62	25.22	15.18
Loss due to radiations, etc.........	4.62	5.44	5.52

Air assumed to have 60 per cent. saturation in all cases.

Air for the forced draft in the old boiler room is supplied by two 14-ft. and one 10-ft. steel-plate blowers and in the new boiler room by two turbo- and one motor-driven fan. Ashes and soot in the old boiler room are removed and discharged into a tank 70 ft. above the basement floor, by means of a 5-ft. exhaust fan which runs at a speed of 1440 r.p.m. and is driven by a 100-hp. motor.

Ashes from the new boilers are dumped from the hoppers into half-round tile drains in which they are flushed by mine water into a pit, from which they are taken by a crane and loaded into railroad cars (Fig. 12).

An interesting method of getting rid of ashes from this plant was used about two years ago. As is well known, under the City of Scranton are many coal mines that have been worked out to a large extent, and this power plant is over a mine, the top vein of which is about 130 ft. below the surface. Pillars had been left to support the roof.

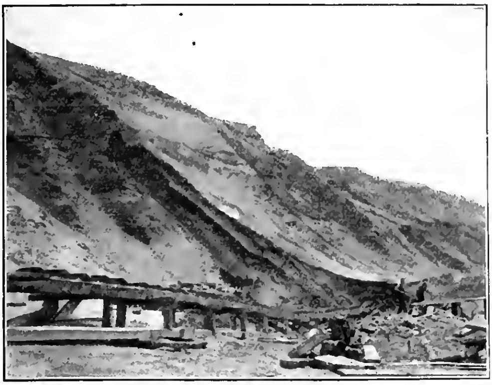


FIG. 8. CULM BANK AND SCRAPER CONVEYOR

huge piles is being reclaimed by passing it through washeries, and is sold in the market in the various sizes of buckwheat. The fine dust, dirt and bone were looked upon as of no particular value, and in some cases were discharged to any stream handy or returned to a bank for rewashing.

The fuel used at the Scranton suburban plant has been through the washing process twice and is so fine that a dry sample taken from the bank and passed through a $\frac{7}{16}$- and over a $\frac{1}{4}$-in. mesh screen gives 8 per cent.; through a $\frac{3}{8}$-in. and over a $\frac{1}{8}$-in. mesh, 6 per cent.; through $\frac{1}{8}$-in. mesh, or dust, gives 76 per cent.. An approximate analysis showed volatile combustible matter 5.02 per cent., fixed carbon 74.98 per cent., noncombustible matter 20 per cent., and a calorific value of 10,500 B.t.u.

This fuel is so fine and dust-like that it is necessary to thoroughly wet it before firing to prevent its being carried over back of the bridgewall before it has had a chance to become completely ignited.

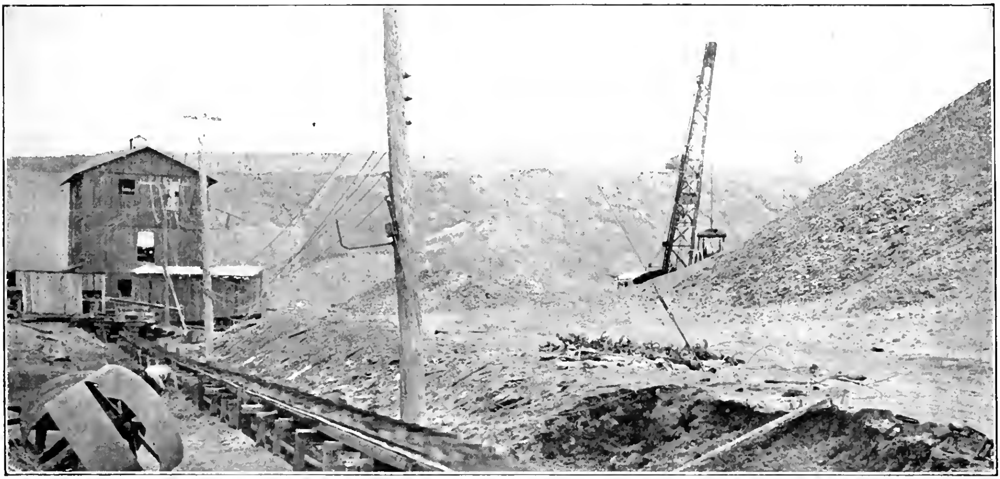


FIG. 9. CULM BANK, ELECTRICALLY OPERATED JIB CRANE AND CRUSHER HOUSE

To prevent the ground from settling under the plant, two 8- and one 10-in. bore holes were drilled through to the three veins, which were worked out, and the ashes from the boilers were flushed into the chambers and passages; thus making a solid support for the plant.

It is proposed to return to this method of ash disposal as the company has about 30 acres of mine surface which is available for filling in. A bore-hole will be drilled in one corner of the ashpit and the ashes flushed to the abandoned mine. There will also be an ash-storage tank of a size to hold about six days' ash accumulation. This is so that the contents of the ash basin and that of the bin can be sent to the mine at one flushing and so decrease the labor cost, as it is necessary to employ men at the outlet of the flushing pipe. It is estimated that with this arrangement one man will do the work formerly performed by six.

FUEL

Culm banks are common in the anthracite region, as up to a few years ago there was no demand for the finer grades of anthracite. Today the coal contained in these

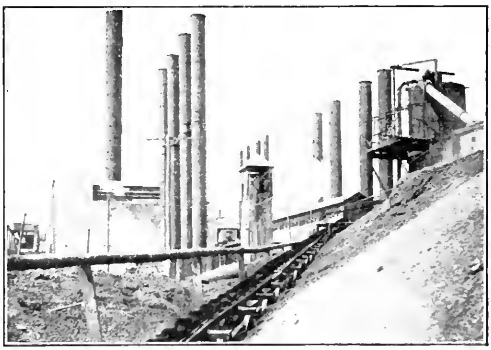


FIG. 10. SCRAPER CONVEYOR DISCHARGING TO OLD BOILER HOUSE

The casual observer would hardly believe that this grade of fuel could be burned to advantage. That it can be utilized in a boiler furnace with good results is shown

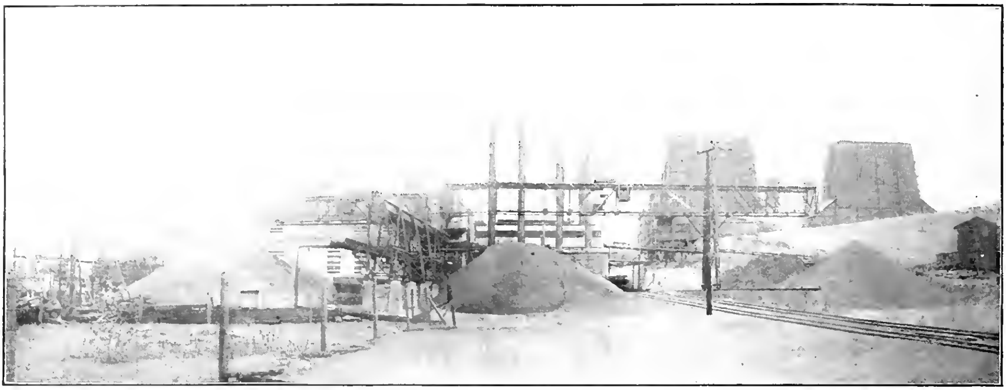


Fig. 11. General View of the Plant, Showing Coal-Conveying Apparatus and Water-Cooling Towers

by a test run on four 480-hp. boilers in the old boiler room. The grate surface per boiler is 168 sq.ft., with 12.5 per cent. of air space. An air pressure of 1.72 in. of water was carried in the ashpit, with a draft over the fire of 0.02 in. and a draft under the damper of 0.45 in. of water. The boiler horsepower developed was 163 per cent. of the boiler rating, with an equivalent weight of water evaporated from and at 212 deg. F. of 6.07 lb. per pound of fuel.

Fuel is carried from the culm bank at the rear of the plant by a 6-in. reinforced chain with scraper every 2 ft. The conveyors, which travel at a speed of about 65 ft. per min., are shown in Figs. 8 and 10. The culm is taken to a crusher house shown at the left in Fig. 9, and as it contains considerable rock, it is taken to the top of the building and dumped into a $^3/_4$-in.-mesh revolving screen. The material passing through goes to the conveyor line, Fig. 10, which discharges to the boiler house where it is hand-fired to the furnaces. What does not pass through the screen goes to a pair of 24x24-in. chestnut rolls, and then drops into a second set of rolls of the same size, which reduces it to pea-coal size. It is then returned to the elevator and passed through the screen in order to mix it with the finer fuel coming from the culm pile. An electric jib crane with a 2-ton clamshell bucket is used for handling the culm from the pile to the conveyors.

Fuel for the new boiler room is obtained by rail from another culm pile owned by the company, and is stored in the yard close to the boiler house. Here it is handled by a 10-ton, three-motor traveling crane equipped with a two-ton grab bucket, Fig. 11. This takes the coal from either the cars or the bins and discharges it into a crusher, which passes it to a 30-in. belt conveyor, Fig. 12. The latter de-

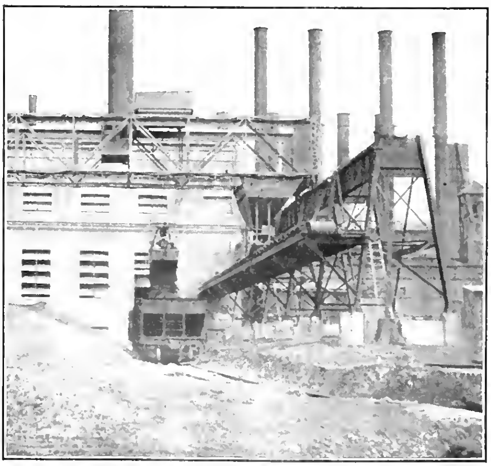


Fig. 12. Ash- and Coal-Handling Apparatus

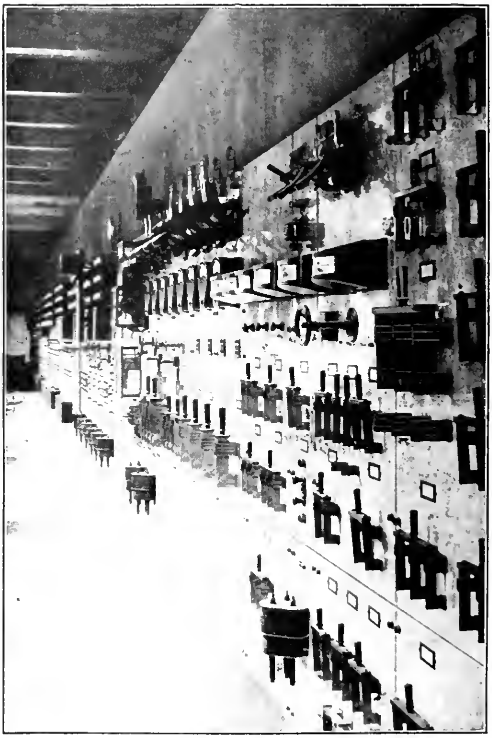


Fig. 13. Station Switchboard

posits the coal onto a 32x32-in. overlapping bucket conveyor, which elevates it to the top of the building and dumps it into either one of three 24-in. belt conveyors that discharge into the bunkers. These conveyors have a capacity of about 120 tons of coal per hour and are equipped with automatic self-reversing traveling trippers arranged so that their travel may be controlled by hand.

Steam Heating

The exhaust-steam system of the company is one of the largest in the United States. It comprises over 15 miles of mains ranging from 2½ to 22 in. in size. Both the illuminating and suburban plant supply steam to the system, and it has been found advisable to carry the heaviest back pressure on the illuminating plant, which is nearest the center of distribution. With a winter temperature of 25 deg. F., the pressure at the suburban plant is carried at twice that at the illuminating plant. With lower atmospheric temperatures down to 10 deg., the pressure gradually changes until the suburban plant has three times that of the other, and below 10 degrees the difference in back pressure is four times greater than that at the illuminating plant.

One pound pressure is carried at the point of delivery to a building. If the pressure drops below this the engineer is at once notified. With the beginning of the heating season, the exhaust steam from one cylinder of the twin engine at the illuminating plant is turned into the heating main; exhaust steam from the compound engine at the suburban plant is turned into the main, but the back pressure on the low-pressure cylinder is not increased above 15 lb. In case it is necessary to carry more than 15-lb. pressure, owing to a drop in atmospheric temperature, the twin engine is used instead of the compound. If it is necessary to carry more than 15 lb. at all times, the piston of the low-pressure cylinder is removed, the valves are placed in the open position, and the piston-rod hole plugged. This allows any desired pressure to be carried. An auxiliary supply of live steam can be had, if for any

PRINCIPAL EQUIPMENT OF THE WASHINGTON AVENUE POWER PLANT, SCRANTON, PENN

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Turbo-generator	Horizontal, 12-stage	4500-kv.-a.	Main unit	150 lb. steam, 1200 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
2	Turbo-generators	Horizontal, 8-stage	10,000-kv.-a	Main units	150 lb. steam, 1800 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
1	Engine	Cross-compound	36&66x48-in., 3500-hp	Main unit	150 lb. steam, condensing or non-condensing, 100 r.p.m.	Robert Wetherill & Co.
1	Engine	Twin, Corliss	36&36x48-in., 3500-hp	Main unit	150 lb. steam, non-condensing, 100 r.p.m.	Robert Wetherill & Co.
2	Generators	Alternating-current	2000-kv.-a	Main units	100 r.p.m., 4000 volts, 3-phase, 60-cycle	General Electric Co.
1	Turbo-generator	Horizontal—d.-c.	150-kw	Exciter for main units	150 lb. steam, 3775 r.p.m., 125 volts	General Electric Co.
1	Motor-generator	A.-c. and d.-c.	225-hp. motor, 150-kw. gen	Exciter for main units	3-phase, 60-cycle, 4000 volts, d.-c. 125 volts, 720 r.p.m.	General Electric Co.
1	Condenser	Surface	6000 sq.ft. cooling surface	With compound engine	26-in. vacuum	Alberger Pump & Condenser Co.
1	Condenser	Surface	11,000 sq.ft. cooling surface	With 4500-kv.-a turbine	Within 2 in. of barometer, 70-deg. injection water	Alberger Pump & Condenser Co
1	Condenser	Surface	20,000 sq.ft. cooling surface	With 10,000-kv.-a turbine	Within 2 in. of barometer, 70-deg. injection water	Alberger Pump & Condenser Co
1	Condenser	Surface	30,000 sq.ft. cooling surface	With 10,000-kw. turbine	29+-in. vacuum	Wheeler Condenser & Engineering Co
1	Pump	Volute	20-in	With 4500-kv.-a turbine condenser	Turbine-driven, triplex	Alberger Pump & Condenser Co
1	Pump	Volute	28-in	With 10,000 kv.-a turbine condenser	Turbine-driven, triplex	Alberger Pump & Condenser Co
1	Pump	Volute	10-in	With cross-compound engine	Turbine-driven	Alberger Pump & Condenser Co
1	Turbine	Single-stage		Driving 20-in. pump	150 lb. steam	Alberger Pump & Condenser Co
1	Turbine	Single-stage		Driving 28-in. pump	150 lb. steam	Alberger Pump & Condenser Co
1	Turbine	Single-stage		Driving 10-in. pump	150 lb. steam	Alberger Pump & Condenser Co
1	Turbine	Single-stage		Driving turbo and cen. pump	150 lb. steam, 1500 r.p.m.	General Electric Co.
1	Pump	Steam-driven air	8x20x12-in	With compound-engine condenser	150 lb. steam	Alberger Pump & Condenser Co
1	Pump	Steam-driven air	8x20x12-in	With 4000-kw. turbine condenser	150 lb. steam	Alberger Pump & Condenser Co
1	Pump	Steam-driven air	12x30x16-in	With 7500-kw turbine condenser	150 lb. steam	Alberger Pump & Condenser Co
1	Pump	Turbo	No. 70	With 10,000-kw turbine condenser	Turbine driven, 1500 r.p.m.	Wheeler Condenser & Engineering Co
1	Pump	Centrifugal	20-in	With 10,000-kw. turbine condenser	Turbine driven, 1500 r.p.m.	Wheeler Condenser & Engineering Co.
6	Towers	Cooling	24x70-ft each	Cooling condensing water	Fan and natural draft	Alberger Pump & Condenser Co.
2	Towers	Cooling	250 ft. long, 90 ft. high	Cooling condensing water	Natural draft	Wheeler Condenser & Engineering Co.
2	Pumps	Duplex, outside-packed	16x10x18-in.	Boiler-feed	150 lb. steam, automatic control	Scranton Pump Co
2	Governors	Kitts		On boiler-feed pumps		Kitts Mfg. Co
2	Heaters	Stilwell, open		Heating boiler-feed water	Using exhaust steam	Platt Iron Works Co
2	Motor-generators	Synchronous motors, d.-c. gen	1400-hp—1000-kw.	Railway service	550 volts, 514 r.p.m.	General Electric Co.
2–3	Motor-generators	Synchronous motors, d.-c. arc gen.	250-hp	Arc-light service	4000 volts, 6.6 amp., d.-c., 514 r.p.m.	General Electric Co
1–2	Motors and generators	Synchronous motor, d.-c. arc gen.	186-hp	Arc-light service	4000 volts, 6.6 amp., d.-c., 514 r.p.m.	General Electric Co.
1	Motor-generator	Induction motor, d.-c. gen.	150-hp motor, 100-kw. gen	Motor service	250 volts, d.-c., 580 r.p.m.	Westinghouse Elec. & Mfg. Co
1	Motor-generator	Induction motor, d.-c. gen.	300-hp motor, 200-kw. gen	Motor service	250 volts, d.-c., 580 r.p.m.	Westinghouse Elec. & Mfg. Co
1	Engine	Marine	10x18x10-in	Drives 125-volt generator	150 lb. steam, 340 r.p.m.	General Electric Co
1	Generator	Direct-current	100-kw	Exciter unit	125 volts, 340 r.p.m.	General Electric Co.
4	Boilers	Water-tube, Sterling	480-hp	Steam generators	150 lb. steam, Dutch-oven furnaces	Babcock & Wilcox Co.
4	Boilers	Water-tube	600-hp	Steam generators	150 lb. steam, Dutch-oven furnaces	Edge Moor Iron Co
5	Boilers	Water-tube	300-hp	Steam generators	150 lb. steam, hand-fired	Heine Safety Boiler Co.
6	Boilers	Water-tube, double-deck	558-hp	Steam generators	150 lb. steam, will be stoker-fired	Babcock & Wilcox Co.
2	Blower sets	Engine-driven	14-ft. dia	Forced-draft	Variable-speed	American Blower Co.
1	Blower set	Engine-driven	10-ft. dia	Forced-draft	Variable-speed	American Blower Co.
1	Blower	Motor-driven	5-ft. dia	Ash-removal system	Intermittent	American Blower Co
1	Motor	Alternating-current	100-hp	Driving 5-ft. ash blower	Intermittent	General Electric Co.
1	Crane	Jib	2-ton	Handles culm	Motor-operated	Brown Hoisting Machinery Co.
1	Conveyor	Belt	30 in. wide	Handles coal from cars to belt conveyor	Intermittent, motor-driven	Robins Conveyor Belt Co.
1	Conveyor	Bucket	32x32-in	Handles coal from 30-in. to 24-in. conveyor	Intermittent, motor-driven	Mead-Morrison Mfg. Co.
3	Conveyors	Belt	24-in. wide	Handles coal to bins	Intermittent, motor-driven	Robins Conveyor Belt Co

cause the exhaust-steam supply should be insufficient, by reducing the live-steam pressure from 150 to 5 lb. With 10-lb. back pressure about 130,000 lb. of steam is furnished to the system per hour by the suburban plant, and about 50,000 lb. by the illuminating plant at 10-lb. back pressure.

Fig. 13 is a view of the suburban-station switchboard, and Fig. 14 the busbar compartments. The two plants and the substations are connected by tie lines, of which there are four between the two power stations, four from the suburban plant to the Dix Court substation, and one from the latter to the illuminating plant. This arrangement, in connection with the motor-generator sets, makes

Fig. 14. Busbar Compartments

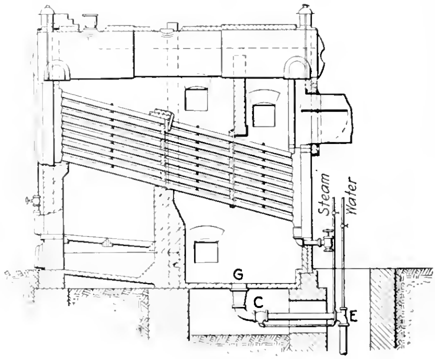
a flexible combination, because in case of an interruption in service the motor-generator sets can be used to generate either alternating or direct current.

There are also two tie lines from the Dix Court substation to the Hampton power plant of the Delaware, Lackawanna & Western R.R. Co., which provide a breakdown arrangement to the advantage of both companies. The conditions are that the Hampton plant has a heavy day load and the illuminating company a heavy night load, and either is supposed to help the other to the extent of 2500-kw. per hr., or more if desired when it is possible to do so.

In building the new power house the principal problems encountered were those of keeping the service up to the standard and at the same time tearing down the old building and constructing the new one over the old. Foundations for new units were built and old ones dismantled, requiring planning weeks in advance. The remodeling was carried on with but one complete shutdown, and that for only about 15 minutes, which reflects great credit upon the engineer in charge. The work cost not far from $2,000,000.

Schutte & Koerting Soot Conveyor

When the soot from the tubes of a boiler is blown down, most of it collects in the dust-settling chamber, from which it is occasionally removed through the clean-out doors. This operation necessarily involves labor and time out of service for the boiler. The illustration shows the application of a conveyor to a boiler setting for removing the soot each time the tubes are cleaned. It is operated by steam pressure and is installed in a pipe line that has connections to the combustion chamber of the



Steam-Operated Soot Conveyor

various boilers, as at *C*. Each connection is furnished with a slide gate, as at *G*, to cut in or out any particular boiler. Only the slide gate to the boiler being cleaned is open. Steam is then admitted to the conveyor, creating a high vacuum, and floating particles of soot are drawn into the system.

Sometimes the amount of soot to be handled is considerable, and as the steam consumption of the conveyor is the same under all conditions, after leaving the conveyor it makes a mixture not readily discharged, and for this reason a special elbow *E* is used. The boss is tapped to take a centrifugal spray nozzle, which injects water to wash the soot down the discharge pipes.

As the water is under pressure and as the nozzle is connected to the discharge in the direction of the flow, it not only helps to wash out the soot, but the water issuing from the centrifugal nozzles gives added velocity sufficient to overcome any reasonable counter pressure.

This soot conveyor is manufactured by the Schütte & Koerting Co., Thompson and Twelfth St., Philadelphia, Penn.

Painting Boiler Drums—In a plant equipped with B. & W. boilers developing 8400 hp., the interiors of the drums were scalded, painted both above and below the water line with silica-graphite paint, and allowed 48 hr. to thoroughly dry. This treatment was repeated every ten months. Pitting stopped, and where it had previously taken six men seven days to clean the drums of one boiler, two men now clean them in a day. This experience is quoted from a letter of the chief engineer of the New York Life Insurance Co., in the April issue of "Graphite."

The Southwark-Harris Diesel Engine

SYNOPSIS—A two-stroke-cycle engine with no scavenging or starting valves in the head, employing a stepped piston for both starting and scavenging and possessing unusual means of fuel control.

The impetus given the heavy-oil-engine industry in this country by the expiration of the original Diesel patents in 1912 has been marked particularly by the number of steam-engine builders who have entered this field. Some, choosing to follow foreign practice, are building under license from foreign firms with modifications to suit local conditions; others have developed what may be termed distinctly American designs. Among the latter may be mentioned the Southwark-Harris Diesel engine, built by the Southwark Foundry & Machine Co., of Philadelphia, from the designs of Leonard B. Harris.

This is a two-stroke-cycle type intended primarily for marine service, but also adapted to stationary work, the engine being somewhat simpler for the latter service, as no reversing is required. Because of the ingenious, yet simple and flexible, control for maneuvering, the marine type will be described.

Unlike most two-stroke-cycle Diesel engines, there are no starting nor scavenging valves in the head, the only opening being for the fuel atomizers, of which there is one to each cylinder in both marine and stationary types. There are two atomizer-actuating levers in the marine type, one for ahead and the other for astern; in the stationary type there is, of course, only one atomizer-actuating lever. This arrangement makes possible a very simple cylinder-head casting.

The pistons, as shown in Fig. 3, are stepped, the lower part serving as a scavenging pump besides acting as a guide in the place of a crosshead. The cylinders are in pairs and each scavenging piston serves the adjacent cylinder of that pair through the passage A, valve V_2, manifold M and port D. This will be understood when it is

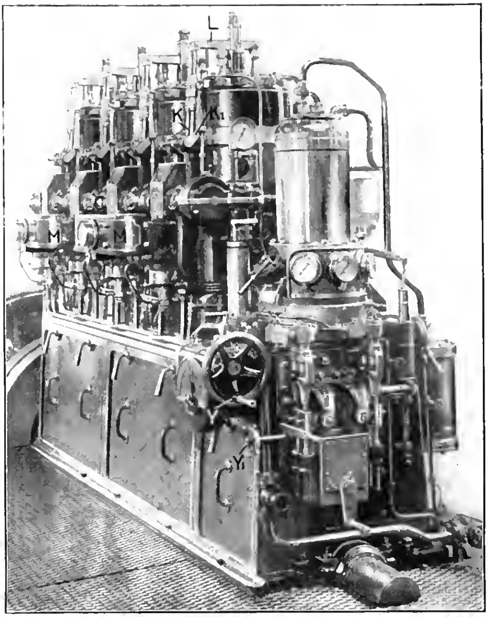


FIG. 2. END VIEW SHOWING PUMPS

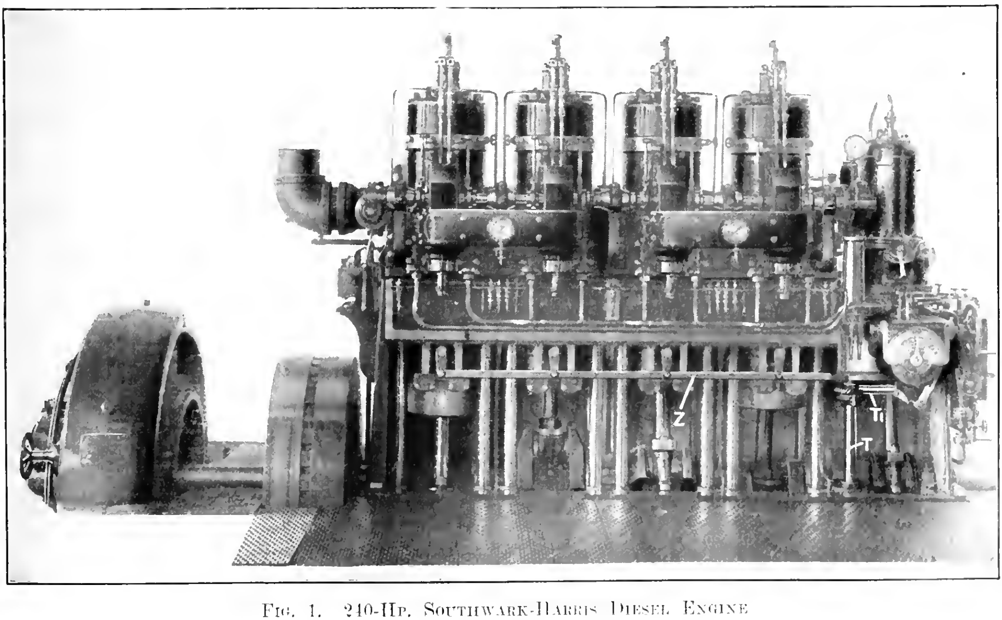


FIG. 1. 240-HP. SOUTHWARK-HARRIS DIESEL ENGINE

remembered that the cranks of a pair are set at 180 deg. Therefore, when the scavenging piston of cylinder No. 1 is traveling upward, compressing the air in the scavenging cylinder, ports and manifold, the pistons of No. 2 are traveling downward, and when No. 2 working piston has uncovered its port *D*, the scavenging air, under a pressure of about 7 lb., will rush in and force the spent products of combustion out through the exhaust ports *E*. The air-delivery valve of cylinder No. 2 prevents the scavenging air of No. 1 from being forced into the scavenging cylinder of No. 2 while its pistons are on the down stroke.

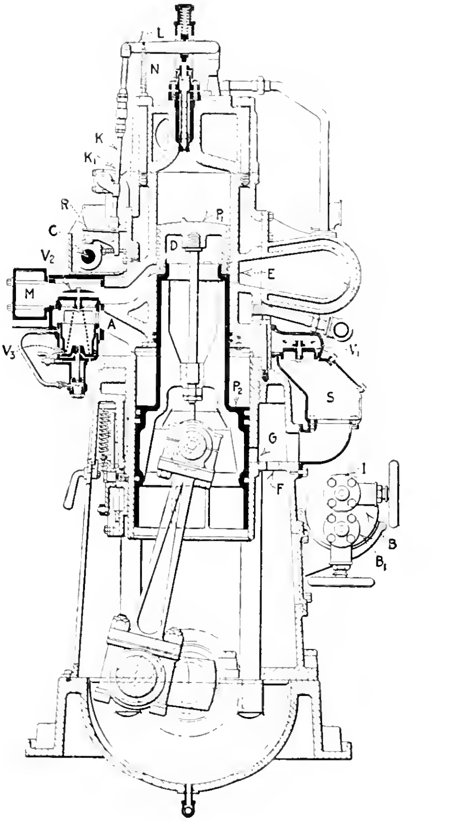


Fig. 3. Sectional Elevation

P_1 is the main piston; P_2, the scavenging and air-starting piston; V_1, scavenging-air inlet valve; A, scavenging-air outlet passage and starting-air inlet passage; V_2, scavenging-air delivery valve; M, manifold; D, scavenging-air inlet ports; V_3, the air-operated intercepting valve; O, outlet for starting air; S, silencer; F, vents; B, injection-air storage bottle; C, camshaft; R, atomizer-actuating rockers; K, push rods; L, atomizer levers; N, atomizer spindle; E, exhaust ports; I, injection air from compressor; B, bypass to starting bottles; K_1, bell crank.

An unusual feature of this stepped piston is its use for starting the engine—a most important factor in marine work, as it avoids admitting cold starting air to the highly heated working cylinders and pistons when reversing and maneuvering. Moreover, as the area of the stepped piston is greater than that of the working piston, starting air of relatively low pressure, 175 lb., can be employed. Since the starting is independent of the working cylinders, the fuel can be admitted to the latter while the starting air is still on. This will be found advantageous when starting under load, as the starting air can thus be used to help out until the momentum has been built up.

Of interest in this connection are the diagrams of Fig. 4. No. 1 is from the scavenging cylinder when starting

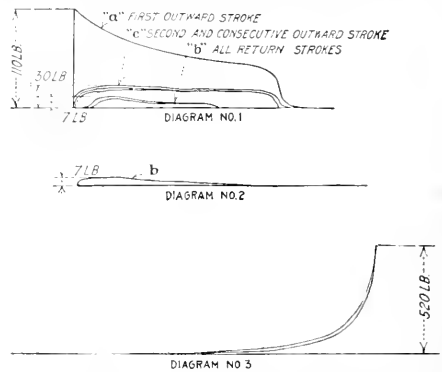


Fig. 4. Indicator Diagrams from Working and Starting Cylinders

with air, while No. 3 was taken simultaneously in the working cylinder. Line *a*, diagram No. 1, represents the first outward stroke, *b* the return stroke, and *c* the successive outward strokes until the starting air is shut off. It will be noted that after the first stroke, a pressure of only 30 lb. is required, owing to the power given back in the working cylinder by the expansion of the compressed

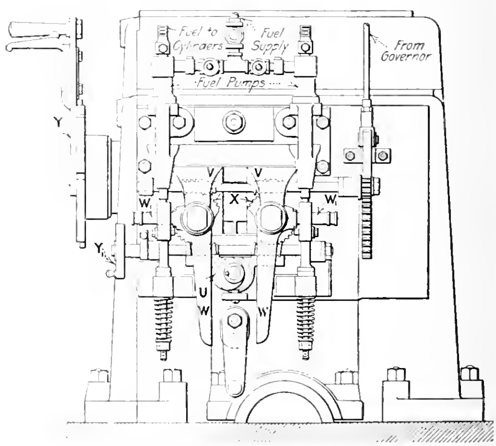


Fig. 5. Showing Fuel Control

air within it. Diagram No. 2 shows the normal working of the scavenging piston.

Starting and fuel-injection air is furnished by a two-stage compressor driven off the main shaft and having a control valve on the suction. The compressor delivers the high-pressure air for fuel injection directly to a steel air bottle mounted at the back of the engine frame. The starting air is supplied to the starting bottles through a reducing valve.

There is a separate fuel pump for each cylinder, making four in all in the engine shown. These are mounted at the end of the engine (see Fig. 2) and the stroke is varied by the governor.

A better idea of the operation of the fuel pumps will be gained by reference to Fig. 5. First, however, it will be necessary to revert to Fig. 1, which shows the pump shaft T_1 driven from the main crankshaft through the vertical shaft T and worm gears. At the end of T_1 is mounted a cam U, Fig. 5, which acts laterally upon the bell-crank levers W; these in turn work the pumps through the arms W_1, working in yokes on the pump stems. The fulcrum pins of the bell cranks are carried on laterally sliding plates V, the movement of which is effected

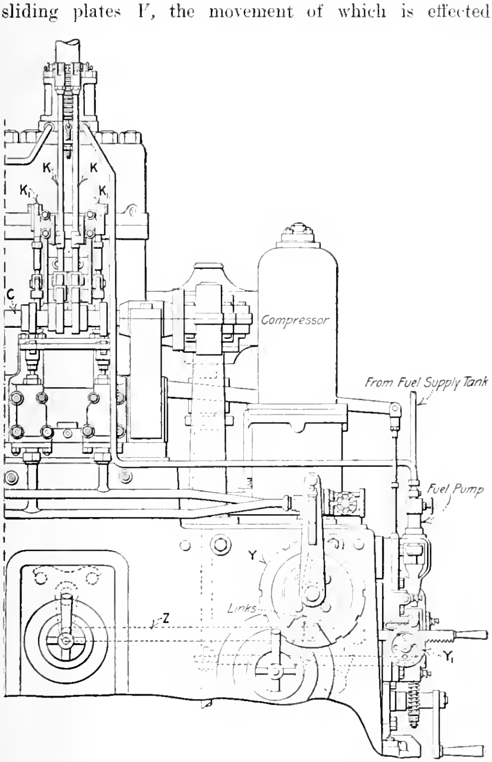


Fig. 6. Partial Side Elevation, Showing Further the Control Features

through two worm spindles, each carrying a pair of right-and-left-hand worms meshing with sectors X. The upper worm spindle extends to the right and connects through gearing with the governor shaft, while the lower worm spindle extends to the left carrying the handwheel Y_1 and connecting through links and a rack (see Fig. 6) with the main control handle Y.

When the pointer of the main control handle is in the central, or "stop," position (see Fig. 1) the bell-crank levers W (Fig. 5) are separated so as not to be actuated by the cam U. Through the arrangement of links shown in Fig. 6, this position of the bell cranks is held ordinarily through the starting period. When the control handle is turned past the first notch to the running position, the lower worm spindle is rotated and, by means of the sectors and slides, brings the bell-crank levers closer together, so that they are actuated by the cam U, and the fuel pumps are set in operation. The governor, now acting through the upper worm spindle, is able to control the position of the bell cranks and vary the stroke of the pumps to suit the load. The small handwheel Y_1 permits manual control of the fuel without altering the position of the main control wheel Y. By this means the engineer is enabled to control the speed of the engine at will, and the governor will maintain control at this speed. This feature is especially useful in marine work when running through a heavy head sea with the engine racing.

In addition to the fuel control through varying the stroke of the pumps, the lift of the fuel atomizers may be altered at will from the control wheel while the engine is running. Referring to Fig. 3, the lower ends of the atomizer push-rods may be swung outward through the arc on the upper side of the rockers, which in turn are actuated by the cams on the main camshaft. It will be seen that when the push-rods are at the extreme right the rockers can be actuated without imparting any motion to the atomizer spindles. When they are moved to the extreme left the atomizers will have their greatest travel. Intermediate positions of the push-rods on the rockers will correspond with definite openings of the atomizers. These push-rods are shifted by means of the bell cranks shown, which in turn are operated through vertical rods connected with the horizontal bar Z (Figs. 1 and 6), also connected with the control handle. The operation is obvious.

A four-cylinder, 240-i.hp. Southwark-Harris engine has just been installed in the yacht "Southwark," owned by C. P. Vauclain, of Philadelphia. The "Southwark" is 98 ft. overall, 16-ft. beam and 7-ft. draft, and on her first trial trip made a speed of about 10 miles per hour against the tide and a head wind, with the engine turning up at 225 r.p.m. Extensive tests are now being made and the results will be available at an early date.

The principal dimensions, horsepower, weight, etc., of the sizes listed are given in the following table:

PARTICULARS OF STATIONARY TYPE

I.Hp.	No. of Cylinders	I.Hp. per Cylinder	Cylinder Diameter, In.	Stroke, In.	R.p.m.	Approximate Weight Without Flywheel, Lb.	Weight per I.Hp., Lb.	Floor Space, Sq.Ft.	Length Overall, Ft. In.
120	2	60	9	13	300	14,000	117	21 6	6 9
240	4	60	9	13	300	25,000	104	34	10 2
360	6	60	9	13	300	35,000	97	45	13 7
225	2	112 5	12	21	200	27,000	120	51	9 8
450	4	112 5	12	21	200	47,000	104	80	15 4
675	6	112 2	12	21	200	66,000	102	110	21
400	2	200	16	28	150		.	116	14 6
800	4	200	16	28	150	. .	. . .	180	22 6
1200	6	200	16	28	150		.	244	30 6

MARINE TYPE

I.Hp.	No. of Cylinders	I.Hp. per Cylinder	Cylinder Diameter, In.	Stroke, In.	R.p.m.	Approximate Weight Without Flywheel, Lb.	Weight per I.Hp., Lb.	Floor Space, Sq.Ft.	Length Overall, Ft. In.
240	4	60	9	13	300	25,000	104	34	10 2
360	6	60	9	13	300	35,000	97	45	13 7
480	8	60	9	13	300	44,000	91 5	56 5	17
450	4	112 5	12	21	200	47,000	104	80	15 4
675	6	112 5	12	21	200	66,000	102	110	21
900	8	112 5	12	21	200	85,000	94 5	140	26 8
800	4	200	16	28	150	. .	. . .	180	22 6
1200	6	200	16	28	150	. . .		244	30 6
1600	8	200	16	28	150	. . .	. . .	308	38 6

Increased the Capacity of the Plant—B. M. Babcock informs us that in his letter under the foregoing caption, May 18 issue, the beginning of last paragraph on page 685 should read: "The grate surface was extended from 6 ft. in length to 8 ft., giving 56 instead of 42 sq.ft. of grate surface," instead of, "the grate surface was extended from 42 in. in length to 56 in."

Priming a Centrifugal Pump*

By E. M. Ivens

SYNOPSIS—Several letters on the troubles experienced in priming centrifugal pumps have appeared recently in Power. *Interested, and drawing on his wealth of experience in this practice, Mr. Ivens presents the following, which shows several ways of overcoming priming troubles. It is a timely, practical and interesting article.*

The several letters that have appeared in Power on the subject of priming centrifugal pumps indicate that much interest centers in that topic.

It is more or less well known that before a centrifugal pump of the suction type can pick up its water, the air contained in the space between the top of the impeller blade or blades and the surface of the water in the suction basin must be expelled. With the removal of this air there occurs, inside and outside of the pump and piping, a difference of hydrostatic pressure which causes the water to rise in the suction pipe and submerge the rotating parts, and immediately, discharge of water begins. The height to which water may be so lifted obviously depends upon the barometric conditions at the time. At sea level the theoretical lift is equivalent to 14.7 lb. of pressure (approximately 34 ft.), but owing to the impracticability of obtaining and maintaining a perfect vacuum, it is impossible to operate a pump having so high a lift. Pump manufacturers seem to have agreed that 25 ft. (dynamic) is the practical limit and advise that less than this be employed if possible.

There are but two principles that may be followed in priming a centrifugal pump and its piping. One is to actually withdraw the air, using vacuum-forming ap-

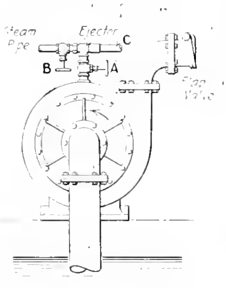


Fig. 1. Steam Ejector for Priming Pump

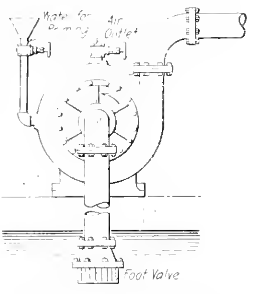


Fig. 2. Displacing Air by Filling Pump with Water

paratus of some kind, and the other is to displace the air with the liquid to be pumped. Fig. 1 illustrates an elementary installation wherein the former method of priming is employed, and Fig. 2, the latter.

In Fig. 1 the air is exhausted by means of the well-known steam ejector placed on top of the pump casing. As shown, the system is closed to the atmosphere by means of the flap valve placed at the end of the discharge pipe. Plainly, this method can be employed only when steam is available, and even then it is objectionable in that the flap valve is with difficulty made air-tight. The method is exceptionally tedious and expensive when relatively high lifts and long suction and discharge pipes are necessary.

In Fig. 2 water is admitted from some outside source, usually an overhead tank provided for the purpose, through the funnel shown and is held by means of the foot-valve attached to the lower end of the suction

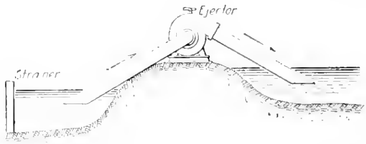


Fig. 3. Typical Location of Pump for Drainage or Irrigation Systems

pipe. An air vent is provided at the top of the volute to prevent "locking." It frequently happens that obstructions find their way through the strainer and lodge on the seat, preventing a complete closure of the valve and making priming temporarily impossible. Expensive shutdowns often occur and considerable annoyance is experienced with foot-valves, when water is drawn from rivers, lakes or other open bodies of water, as is done in rice irrigation and land reclamation.

Centrifugal-pump installations are seldom as simple as those just described. More often, long and angular suction lines are necessary and various other conditions peculiar to the requirements have to be met, such as method of drive, angle of suction and discharge nozzles, stability of water level in the suction basin and the nature of the pumping head.

The writer is fortunate in that he has had the opportunity to design and install a number of pumping plants having a wide range of capacities and pumping heads. With the experience gained it has been found possible to overcome the typical priming difficulties previously mentioned and thus preclude the possibility of annoyance due to loss of vacuum, and at the same time meet the conditions imposed by the nature of the duty. Following are three descriptions of priming methods that have given satisfaction and may be applied to advantage in many places. These will be recognized as embodying the principles already given, but somewhat modified to meet the requirements of each installation.

Fig. 3 illustrates an installation of a low-lift, large-capacity pump such as used in drainage projects. As may be noted, both suction and discharge ends are water-sealed and consequently the use of the troublesome foot and flap valves is dispensed with. A steam ejector is fitted to the top of the pump casing for priming. In the event that steam is not available, a vacuum pump, independently operated, may be substituted. This method of installation possesses other advantages not pertinent here.

*"Power," Mar. 2, p. 291; Apr. 6, p. 481; Apr. 20, p. 550; May 4, p. 615; June 8, p. 778.

Fig. 4 shows a row of motor-driven turbine pumps installed in the water-works plant of a small Louisiana town. The four larger pumps have each a capacity of 250 gal. of water per min. against 100 lb. pressure and are reserved for fire purposes only. The smaller pump is for constant service and has a capacity of 100 gal. per min. against 45-lb. pressure. Current for the motors is supplied by two oil-engine-driven alternators.

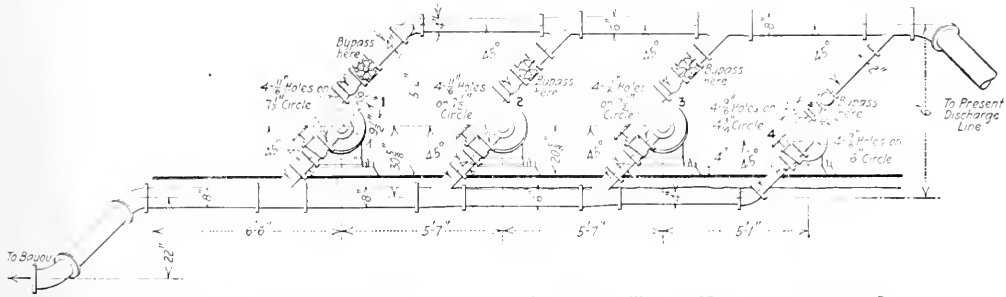


Fig. 4. Layout of Pumping Plant for Small Louisiana Town; Note the Suction Lift

The arrangement of valves and piping is such that any one or all pumps may be placed in service at any time. The suction line is 8 in. diameter, 125 ft. long, and the static suction lift is 12 ft.

These pumps are primed by the method of displacement. Located in the suction line and in the manner shown in Fig. 5, is a surface priming valve designed by the writer. This valve is a combination check and flap valve having all parts made readily accessible by suitably located hand holes. Fig. 6 shows the exterior of the valve and Fig. 7 a vertical cross-sectional view.

The operation of priming and the action of the valve are as follows: Water is admitted from the standpipe

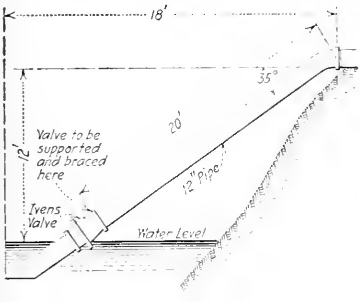


Fig. 5. Application of Valve Shown in Fig. 7

to the pumps through the bypasses indicated in Fig. 4, and the air is vented off through pet-cocks provided on the tops of the pump casings. When water appears at the pet-cocks, the system is filled from the discharge nozzles to the surface valve. Between the valve seat and the water surface there remains an unfilled space or air pocket. Before the column can be started this air must be disposed of, and this is done by the action of the small check valve shown at *A*, Fig. 7, and in the manner later explained.

The motor is now started, and when the full-load speed is reached there appears a tendency to force the contained water out of the discharge, and a surging results. This relieves the pressure above the small check valve, it is opened by the air pressure beneath and air rushes in from the pocket, breaking the partial vacuum created. The column pressure then closes the check valve, and the air admitted by its raising seeks the high point, which is the discharge nozzle of the pump. Continued operation of the motor is accompanied by continued making and breaking of vacuum due to surging, until finally the air pocket disappears. The large flap is then opened by the rising column and occupies the recess provided in the valve body. A free passage is offered to the column, and the only resistance encountered is that caused by part of the weight of the flap.

As shown in Fig. 7, cleaning of the valve seat may be easily accomplished through the handholes and a thorough examination or renewal of all moving parts made by removing the large cover plate to which the flap is attached.

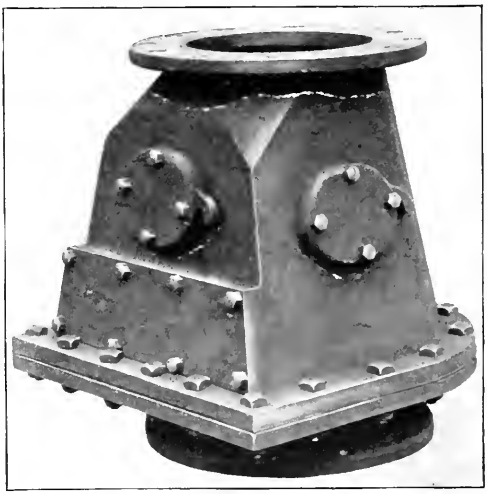


Fig. 6. The Ivens Priming Valve

The writer has used this valve with gratifying results on medium-lift pumps where it was necessary (owing to fluctuating suction lift) to attach the valve direct to the suction elbow, or Y connection, on the pump and some 20 ft. above the water level. Several rice-irrigation plants located on the Mississippi River are using the valve in this way.

A rather interesting system of automatic priming suggested by the writer is employed by a large sawmill in Louisiana. A diagrammatic illustration of the installation is shown in Fig. 8. The equipment consists of a 750-gal., two-stage turbine pump, direct-connected to a 100-hp., 2200-volt, three-phase, 60-cycle, 1740-r.p.m. motor, and a 6x4½-in. vacuum pump, gear-driven by a 5-hp., 220-volt, three-phase, 60-cycle motor. The plant is located on the Mississippi River about a mile and a half from the electric generator which furnishes the current for the motors.

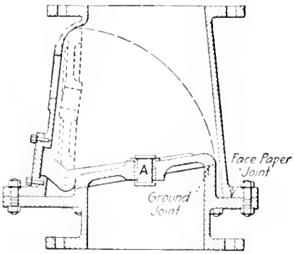


FIG. 7. SECTION OF IVENS PRIMING VALVE

The suction of the vacuum pump is connected to a chamber and thence to the discharge nozzle of the pump, as shown. The chamber is made of 6-in. pipe and contains a cedar float suspended by a rod attached to a check valve above. The weight of the float and rod is sufficient to hold the check open under 25-in. vacuum when the chamber is empty. If, by any chance, water should enter the chamber, the buoyancy of the float permits the check to close immediately. This prevents water being drawn into the cylinder of the vacuum pump.

The motor operating the vacuum pump is equipped with a pressure-control switch, the pressure pipe of which is connected to the discharge nozzle of the centrifugal pump. Operation is as follows:

Both motors are started simultaneously and the vacuum pump rapidly withdraws the air, priming the system. When a pressure of 10 lb. is reached in the water-discharge piping, the pressure switch actuates and the vacuum pump is stopped. If, at any time, the pump should lose its column, the vacuum pump starts automatically and the process of priming is repeated.

This installation has no regular attendant, and difficulty has never been experienced since first starting.

It is quite true, as Mr. Palmer says (POWER, Apr. 6 issue), that considerable trouble has been experienced in priming centrifugal pumps, but often the operator is to blame and frequently the fault lies in the method of installing the equipment. In answer to trouble calls the writer on two occasions traveled several hundred miles, to find the pump rotating in the wrong direction. On a number of other occasions the trouble was caused by leaky suction pipes or air locking due to the accumulation of air at high points in the suction piping. One unpleasant experience was caused by the designer's disregard of frictional loses, and an attempt was being made to operate several pumps with a suction lift far in excess of that theoretically possible. In every instance the operator first stated that the pumps were defective and then, after his difficulty had been overcome for him, it was "priming trouble."

Characteristics of Radiation Pyrometers

The Bureau of Standards will have ready for distribution shortly a paper entitled "Characteristics of Radiation Pyrometers." A careful study of this type of temperature-measuring instrument was considered urgent on account of the extensive use of radiation pyrometers in the technical industries. These instruments are widely used in the temperature control of the various processes involved in iron and steel manufacture, alloy-foundry work, glass, ceramics, and brick manufacture, smelting, gas works, steam generation, lamp manufacture, etc.

Many of the instruments examined show different temperature readings for different focusing or sighting distances. Errors thus occasioned may amount to several hundred degrees. The effect of dirt upon the lenses and mirrors is of serious importance. The question as to whether the pyrometer absorbs all the heat radiation falling upon it is discussed, and the theory of the instrument and the connection of its behavior with the theoretical radiation laws are given.

The bureau receives a large number of these instruments for test and standardization from various technical industries throughout the country. Heretofore, this testing required about three days for a single instrument, on account of the difficulty in heating a furnace to an exactly uniform temperature. A new method has been developed which permits a satisfactory standardization of a radiation pyrometer within one hour. Many suggestions are given for minimizing the errors to which the pyrometer is subject, and it is shown that this type of instrument, suitably designed, adequately calibrated and correctly used, is a trustworthy pyrometer having many advantages over other types of temperature-measuring devices, both for scientific and technical use.

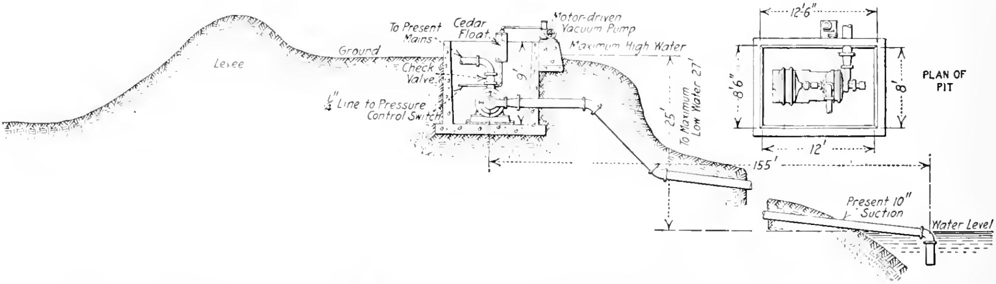


FIG. 8. PUMPING PLANT HAVING MOTOR-DRIVEN AIR COMPRESSOR WHICH AUTOMATICALLY KEEPS PUMP PRIMED

Firebrick for Boiler Settings*

By William A. Heisel†

SYNOPSIS—An unusually complete, interesting and highly valuable article on an important subject about which little has been written.

Chemically pure fireclay consists of silica and alumina and combined water. Pure fireclay is called "kaolinite" and consists of about 40 per cent. of alumina, 46 per cent. of silica and 14 per cent. of combined water. It acquires in its travels various impurities, such as iron, lime, magnesia, alkalies, soda and potash, together with more or less organic material.

In this country the most important fireclays are found in Kentucky, Pennsylvania and Missouri.

Physical and Chemical Properties of Fireclays

Flint clays are more nearly chemically pure than plastic clays, because of the difference in their formation. The flint clays have practically no plasticity, while the plastic clays vary from slightly to highly plastic.

The colors of plastic fireclays range between the two extremes of white and black, with such intermediate colors as gray, brown and olive. Flint clays do not show a marked color difference, being either white, gray or mottled black. The color of clay is not always a safe guide in its selection for quality, for in some cases it indicates the amount of contained impurities in both the flint and the plastic clays.

Impurities in Fireclays

The impurities in fireclays occur in various forms—the iron, for instance, as pyrites (sulphite of iron), sometimes in large particles widely distributed, and at other times in small particles uniformly distributed. Again, the iron occurs as carbonate of iron, usually in large, hard lumps. The lime occurs as gypsum and as limestone. When magnesia occurs, it is usually associated with lime in limestone. The alkalies enter in the form of mica or feldspar.

The amount of contained impurities in the finished product, firebrick, is not always a reliable indication of the temperature at which the brick will soften, as is clearly shown by the curves representing the result of 44 different tests.

Method of Manufacture

The impossibility, on account of excessive shrinkage and consequent liability to warpage, of using all raw clays makes necessary the calcining, or burning, of some of them, preferably the flint clay, to obtain a high-grade product. The amount to be used of this calcined, or burned, clay is determined by the physical and chemical qualities the manufacturer is striving to obtain for the character of work. As flint clays and calcined clays have no plasticity, a bonding material is necessary, this being supplied by a plastic clay. The amount of the latter used for bonding varies from 15 to 50 per cent. In some classes of work, practically all plastic clay is used.

Firebricks are used in innumerable ways—in the various metallurgical furnaces, in the manufacture of lime, cement and glass, and in the settings of steam boilers.

The last practice, particularly in later years, has demanded a higher grade of brick than was satisfactory under the former milder working conditions. The more general use of mechanical stokers, their greater degree of perfection and the more thorough knowledge by the operators of the theory of combustion, have developed conditions which have made high-grade firebricks much sought for. The development in the manufacture of firebricks has not kept pace with the comparatively more marvelous increase in the severity of service in boiler and stoker installations.

Boiler-Furnace Conditions

With the present modern equipment much improved combustion occurs, much higher temperatures prevail and higher ratings are obtained than were possible with the less intelligently designed and operated installations and boiler and stoker equipment of former years. Whereas some years ago a 50-per cent. overload on a boiler was about the maximum to be expected, it is now not uncommon to see in the larger plants stoker-fired installations operated at 100 to 150 per cent. over their commercial rating.

While not much thought was given to the selection of firebrick in previous years for boiler work, and a brick of mediocre refractoriness would show reasonable life, the best today is none too good under the present extremely severe operating conditions. It is not to be inferred that much progress and improvement have not been made in the manufacture of fireclay brick, as a superior article is today being made by most manufacturers, and continued advancement may be expected.

It would seem from present-day experiences that the capacity of most stoker-fired boilers is limited only by the ability of the firebricks to withstand particularly the extreme temperatures generated. As an example of high temperatures: In some stoker-fired furnaces a quantity of platinum was melted in a graphite crucible, the melting point of platinum being 3191 deg. F. This temperature approaches closely the melting point of pure fireclay, which is 3326 deg. F.

Refractories with High Melting Points

Efforts have been made to substitute materials with melting points higher than the commercial fireclay brick, but because of the inability of these materials to withstand certain other conditions, such as sudden heating and cooling, pressure at high temperatures, the action of certain gases of combustion, and the chemical action of certain fused ash, these substitutions have failed to realize the theoretical expectations. The other refractories that have been given a trial in boiler work are silica, bauxite, chrome and magnesite.

Silica bricks, made from silica rock, or ganister as it is sometimes called, and bonded with about 2 per cent. of lime, have the particular objection for use in boiler-furnace work, especially in arches, of being unable to

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*Paper before the Ohio Society of Mechanical, Electrical and Steam Engineers.

†With the Charles Taylor Sons Co., Cincinnati, Ohio.

withstand sudden changes of temperature without spalling. The lime used as a bond in silica bricks combines with the silica and makes a product that is hard and dense after burning. Although silica bricks are highly refractory and should stand high temperatures, it would not be practicable to maintain, in boiler furnaces, conditions that would be favorable to their long life and general use. In furnace side-walls silica bricks, because they are an acid material, would be readily attacked by the usually basic ash, the ash of nearly all coals being high in ferrous oxide (oxide of iron) which is basic in relation to silica.

Silica bricks would stand the service well with an oil or gas flame, as far as chemical action is concerned, but here again the sudden change in temperature following the sudden turning on or shutting off of the burners would cause a rapid deterioration through spalling. With coal the furnace temperature is not so suddenly reduced, as the fuel bed acts as a reservoir of heat.

A silica brick in comparison with a fireclay brick has a permanent expansion; that is to say, upon repeated heatings its size increases up to a certain point, the rate of increase varying with the different makes of silica bricks. For example, upon the first heating it increases, say, to about 0.04 in., upon the second heating to about 0.03 in., and upon the third to about 0.02 in.—a total of 0.09 in. If, then, it had reached its limit, further heating would increase the size only temporarily, the brick reducing to its final size upon being cooled. The tendency of the firebrick is to become slightly smaller, if anything, upon repeated heatings.

Springs in Arches Unsuccessful

Silica bricks have been used in the arches of heating furnaces in metallurgical operations, and the expansion of the silica arch taken care of by sets of springs placed on the sides of the furnaces at each end of the arches. This is a costly and an annoying arrangement, so we are told, and so far as known is not sufficiently satisfactory to meet with general adoption.

Chrome and magnesite bricks, used in basic openhearth furnaces and other places where the temperature and chemical action is severe, would seem to be ideal for use in boiler side-walls, but because of their inability to withstand much pressure at high temperatures and the heating and cooling effects, these materials are out of the question.

On bauxite bricks experiments are being made to determine their value as a refractory in boiler settings. It has been difficult thus far to make a product of bauxite which will give uniformly good results, by reason of the wide variation in the chemical composition and physical properties of the raw material and the difficulty met with in attempting to control the crude ore. On account of the value of bauxite to the aluminum manufacturer the fields of the best ore are owned by the aluminum industry, and what is available to the brick manufacturer is of inferior quality. Also, more than the usual methods must be employed in reducing the great shrinkage in bauxite, which requires calcining at high temperatures. Bauxite brick, too, is likely to spall.

From the discovered deficiencies of these special refractories—namely, silica, magnesite, chrome and bauxite—for boiler furnace and arch practice, it would appear that the manufacturer who is striving to develop an extraordinarily refractory product for this class of service must confine himself in his experiments to find the proper combination of fireclays.

Selection and Use of Materials

Much trouble with firebrick settings is due to improper selection and ignorance in the use of the materials, and also in many cases to lack of care in constructing and laying up the work. In arches, particularly where the service is hard, care should be taken that all bricks in the same row are of the same thickness and shape, as it is difficult to secure high-grade brick of the same thickness and uniformity. This fact is apparently recognized by the United States Government, which makes liberal allowances for variation in the size of firebrick in its specifications. In a maximum of 9 in. in length it allows a minimum of 8¾ in., although this wide variation should not occur in any one lot of brick and is a variation that the manufacturer would not be proud of.

A conscientious mason will carefully select his brick, culling out those of irregular shape, and will try the selected brick dry over the arch-form with a straight-edge. Then he dips them in a creamy solution of fireclay and rubs them in place. Bricks of uneven thickness should be cut and rubbed. If this care is not exercised large fireclay joints will be required and the life of the arch seriously shortened.

Wedges should be used as often as is necessary to keep the bottoms of the bricks in even contact with the arch form, and the key-brick course should make a true fit from top to bottom. The key brick should be driven from 1 to about 1½ inches, depending upon the hardness of the brick and the width of the arch.

Fireclay Mortar and its Relation to the Life of Firebrick

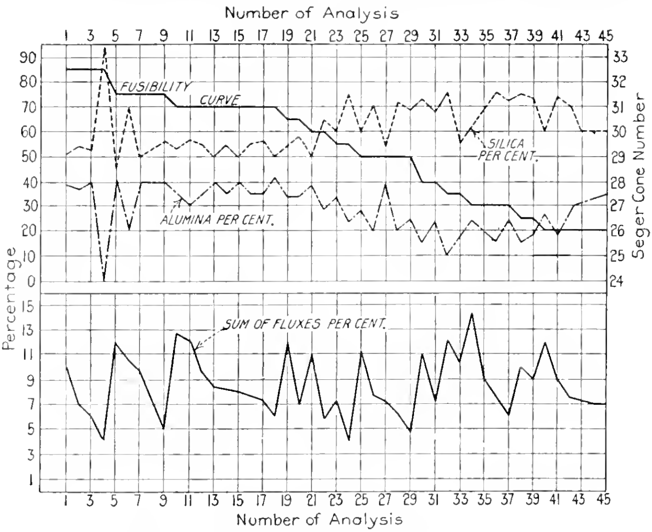
All firebrick, whether fireclay or special refractories, should be laid in mortar of nearly the same composition as the brick itself to prevent a fluxing action, such as would be caused if, for instance, siliceous mortar were used with magnesite brick. In the case of fireclay bricks, a good grade of fireclay should be used, the refractoriness of which is practically equal to that of the bricks themselves. This precaution is sometimes not taken, with the result that the fireclay begins to melt at a lower temperature than the bricks will stand, and in melting dissolves the bricks adjoining it, much the same as a piece of copper is melted at a temperature lower than its natural melting point when placed in a pot of melted babbitt metal. Inferior clay used in an arch may therefore result in the softening of the bricks and the collapsing of the arch.

Foreign materials, such as salt and lime, added to fireclay to make it soften and fuse the brick together is, in the manufacturer's opinion, a practice not to be recommended, as both of these materials are active fluxes and readily attack the bricks, especially at high temperatures.

In mixing fireclay to be used as a mortar, best results can be obtained by using a certain amount of fire sand; that is, pulverized calcined clay or bricks. This prevents shrinkage of the raw clay and the crumbling out of the joints. Regarding the benefits derived from boiling fireclay, there is a difference of opinion. Some boil the clay, feeling that it takes out the shrinkage, although there is not enough heat in the boiling process to take out any appreciable shrinkage; but boiling results in a complete mixture, making it free from lumps and putting it in shape to make a tight job.

Laboratory Tests Compared with Practical Tests

In selecting bricks to be used in furnace practice, the manufacturer is often asked for an analysis of the brick he intends to furnish in order that the user may judge as to its quality. The analysis alone of a brick does not afford the best way to judge its suitability for the work intended, as the analysis merely shows its composition without giving any information as to its physical properties, which are usually more important than the chemical composition. The analysis does not reveal the way in which the impurities occur—an important item in considering the temperature to which the bricks may be subjected without danger of failure. The curves show clearly that the melting point cannot be judged by the analysis alone. On these curves showing the fusibility of 44 different firebricks, the percentage of silica, alumina and total fluxes present in each brick, it will be noted that brick No. 5 melted at Cone No. 31½, or 3200 deg. F., and had 42 per cent. of alumina, 47 per cent. of silica, the sum of fluxes being 12 per cent.; brick No. 21 melted at Cone 30, or 3046 deg. F., and had 50 per cent. of silica, 38 per cent. of alumina, the sum of fluxes being 11 per cent. It would seem from the similarity of these analyses that these two bricks would melt at the same temperature, but owing to the difference in the physical structure one is more refractory than the other.



Results of Analysis of Forty-Four Firebrick

To secure a sample for determining in a laboratory the melting point of a firebrick, the usual method is to knock a corner, about one inch high, off a brick, the bottom of the test piece so secured forming a triangle, each side of which measures approximately one-half inch. This piece, together with three small cones, each having a different known melting point, is then placed in an electric furnace for observation as the temperature of the furnace increases. When the sample piece of firebrick, in the form of a small pyramid, loses its shape, it is considered melted, and the highest pyrometric cone which is melted alongside of the test piece indicates the melting point of the brick. For example, if three pyrometric cones were used, each having a different melting point, say 3218, 3254 and 3290 deg. F., and the 3254 deg. cone was left unaffected, while the 3218 cone was melted at the time the brick sample started to melt, we would know that between 3218 and 3254 deg. F. was the melting point of the sample. This way of determining the melting point has the advantage over other methods using pyrometers, inasmuch as these cones take into account the time element; time should be considered in determining the softening temperature of any fireclay product, as a brick which melts at a high temperature, say in one day, can be melted at a much lower temperature by holding the heat for a longer time.

The melting point is sometimes determined by means of an optical pyrometer. This is also a good method, if all tests are carried out in the same length of time, so as to be comparative.

The temperature at which a piece of firebrick melts in an electric testing furnace is often higher than this same brick will stand in a boiler or commercial heating furnace, as in such furnaces there are conditions, such as the action of the slag and furnace gases, which are not present in the small electric furnace test. On the other hand, in the electric furnace the brick is surrounded by a high soaking-in heat, no chance being afforded for radiation, as is the case with bricks in furnace walls in some types of furnace arches. The service due to heat alone is not as severe on firebricks placed in walls exposed to the atmosphere as in partition or division walls between furnaces, where the heat i. acting on both sides of the wall. That this is true is demonstrated by the longer life that arches exposed to the air on one side will show over those subjected to fire on both sides. Although brickwork will show longer life where there is such cooling action, this gain is usually had at the expense of lost heat energy.

United States Government Tests

Another way to determine the softening point is by means of the government load test. This consists in placing a brick on end, loaded 50 lb. per sq.in. of cross-section, and in having it successfully stand a temperature of 2400 deg. F. for one hour without showing any deformation, checking, spalling, or contraction greater than ½ inch in length. In making this test the heat is brought up so that 2400 deg. F. is reached in four hours, and this temperature is maintained for another hour. Another government test consists of breaking up a brick and subjecting the pieces to a temperature of 3200 deg. F., which it must stand without softening. Under the load test, if the brick contains many impurities, its fluxing action will occur at this or a lower temperature and cause the brick ^ soften, thereby allowing it to compress under the total weight of 562 lb. This load test is better than the melting- or softening-point test, as it shows more clearly the temperature at which the brick commences to soften, and this is the temperature which the user of firebrick, especially firebrick for boiler practice, is interested in. It is also a more comparative test than the melting-point test, as the time element is always the same and it is merely a case of measuring the length of the brick before and after testing to determine the contraction; whereas in the melting-point determination the question always arises at just what point the brick is considered melted, that is, whether it is melted when the tip and sharp corners of the pyramid become rounded or whether it is melted when the piece of brick is seen to distinctly flow, the difference in temperature between these two points being considerable, as the viscosity of most brick is high.

Conductivity of Brick Important

The conductivity of firebrick is a property seldom mentioned in considering brick for boilers; but tests have shown that a hard-burned, dense brick possesses a higher conductivity than a soft, open-grain one. The chemical analysis does not provide information as to the rate at which a fireclay brick will conduct heat, this property depending upon physical makeup.

Some Causes of Failure

A not unfrequent cause of trouble in arches is spalling, which is a popping-off of large pieces of the bricks. This sometimes results from arch bricks becoming frozen or wet through a leaky boiler tube, header cap, drum seam or water used in washing out or in turbining the boiler tubes. With this condition unnoticed or unknown to the operators, a hot fire is started before the bricks have been slowly dried, with the result that some, if not all, of the bricks crack and pop off. Once this action is started in any part, the balance of the arch is usually doomed to early destruction. This is because the adjoining bricks are exposed on more than one side to the action of hot gases, more area is receiving heat and more heat is being absorbed by these bricks than they have capacity to take care of by conduction and by final radiation to the atmosphere or a cooler zone of the furnace.

Why Spalling Happens

Spalling, again, may be caused by the natural inability of the brick to withstand the high temperatures of large volumes of slowly moving or confined gases. The ends of the brick are absorbing heat faster than they can conduct it to a comparatively cooler zone, consequently the clay in the exposed ends becomes vitrified, the elasticity of that portion is lost, and when further heating and cooling take place the difference in the rate of expansion and contraction between the two parts of the brick causes a separation, the vitrified section dropping off unless held temporarily by the compression of the arch.

Spalling is also the result of strains due to inrushes of comparatively cold air striking the incandescent bricks and suddenly contracting them. These cold blasts occur when fire-doors are held open too long, or when hand- or stoker-fired grates are improperly operated and large holes in the fuel bed permit a strong draft to pull the cooler outside air into the furnace.

A test sometimes resorted to by prospective buyers to determine the value of a brick for archwork, is one wherein the sample is placed in the furnace, brought up to a red heat, and suddenly dropped into a pail of water. If it does not crack, it is assumed that it will not spall in service. This is no indication of the ability of a firebrick to withstand the heating and cooling strains in an arch, as the conditions are not the same. In heating a brick in an open fire it expands uniformly in all directions, and when thus suddenly cooled the contraction is likewise equal in all directions, whereas a brick in an arch is exposed to high temperature on one side and to comparatively cool gases on the other. When the bricks in an arch are suddenly cooled by a draft of cold air, the upper ends contract at a different rate from the remaining portion.

It is found that a close-grained, hard-burned brick is usually more susceptible to this action than a soft, open-grained, or porous, brick, which is more elastic and better able to adjust itself to this expansion and contraction. The theoretical explanation of this is that in a close-grained, or fine-ground, hard-burned brick, the molecules are more closely associated and heat is more rapidly transmitted from one molecule to the other. Open-grained bricks for this reason act, we might say, more as insulating material, tending to repel the heat instead of absorbing it. When making this comparison we have in mind only such bricks as are made of highly refractory clays, as no matter how carefully a brick may be constructed, if it has not clays of such refractoriness as will resist the action of the temperatures applied, it will be useless for the work.

Another trouble with arches is caused by the improper setting of the skewbacks, through a failure to pack them tight against the buckstays at the sides of the furnace, or using with them, as filling-out pieces, firebrick which come up tight to the buckstays and are set snugly together without fireclay joints.

Allowance for Expansion and Contraction

Arches should be designed and constructed so that they will meet no interference when expanding or contracting. They should not be tied into front-wall brickwork or carry the weight of any other part of the setting. One also should strive to secure as nearly as possible the same conditions both under and above the arch for its entire length. In other words, if an arch within a boiler setting is made a continuation of the dutch-oven arch outside the setting, there is liability of the arch breaking. The extension furnace arch has its upper side exposed to the cooler atmosphere, while the inner arch is in contact with the hot gases of combustion on both sides. The rate of expansion of these two differently located parts of the arch, it is evident, will be different.

Spring of Arch

Arches with too much spring frequently buckle and break their backs when they rise by expansion. A rise or spring of 2 in. to the foot of furnace width is the commonly adopted practice. This gives a reasonable spring to the flatter arch and acts as a resistance to expansion, keeping the arch tight.

Rounding off the last, or end, bricks in an arch frequently lessens or remedies the trouble caused by the spalling off of these ends, and due to the gases making a short, right-angled turn and throwing an intense heat into the corner of these bricks, which have two of the faces exposed.

Different Brick for Different Parts of Furnace

In considering firebricks for different parts of a furnace, it must be borne in mind that the conditions in side walls are different from those in an arch and that a brick which often gives excellent service in arch practice does not always give correspondingly good results in the side walls of the same furnace. It is therefore well in some cases to use two kinds of brick rather than to try to make one kind do for both places.

Arch practice requires a brick that is not only sufficiently refractory to withstand high temperatures, but one that will withstand these temperatures under much compression, that will not spall and that has a minimum amount of shrinkage and expansion.

In the United States Government tests made on various bricks throughout the country, many bricks were found which would hold up under a temperature test of 3000 and 3200 deg. F. without softening, but only a few, we understand, stood the heat test under pressure.

Furnace side walls are not so much affected by spalling as they frequently are through the chemical action of the fused ash and distilled gases of some coals. Generally speaking, where coal is used as fuel, furnace side walls require a brick less porous and soft than would be used in an arch, in order to stand abrasion from the fire tools and the cutting action of the clinkers when being disturbed or removed.

Arch Blocks

Blocks for arches and side walls are sometimes used and in many cases give better results than standard 9-in. brick. They have the advantage of reducing the number of joints and parts to lay, and the radial arch blocks turn true to the given circle. These blocks are usually made on special orders of a certain combination of clays, are tried for fit, and by some manufacturers machined down, where necessary, on a carborundum wheel to secure level sides and to insure a good fit. On account of the greater mass of contained material, these blocks must be carefully and slowly dried on a cool floor and painstakingly burned.

Turbo-Reduction Gear

The planetary type of gear shown in Figs. 1 and 2 is a recent development of the Turbo-Gear Co., Baltimore, Md. It is designed to be used as a speed-reducing or speed-increasing gear and will run either right- or left-hand. The driving and driven shafts rotate in the same direction.

The gear consists of a large internal double-helical gear made of an openhearth steel forging. A double-helical pinion cut integral with the high-speed shaft is made of chrome-vanadium. The intermediate double-helical gears are made of manganese-bronze and are mounted on hardened and ground forged-steel shafts which are secured to the cast-steel slow-speed member by means of a taper fit and Woodruff keys.

The slow-speed member to which is secured the slow-speed shaft is mounted on two heavy-duty ball bearings, one on each side of the gears, and supported directly by the heavy housing. The slow-speed member, the shaft carrying the intermediate gears and the high-speed shaft and pinion are independent of each other for support and each is supported directly by the housing.

The housing is made of cast iron, horizontally split to afford accessibility to all internal parts. It is heavy and well ribbed to provide a rigid support for the gear members in order to secure quiet operation. Caps protect the high- and low-speed bearings from dust.

The high-speed shaft has a central passage through which the oil is pumped, and a continuous stream is sprayed on the gears through radial passages in the

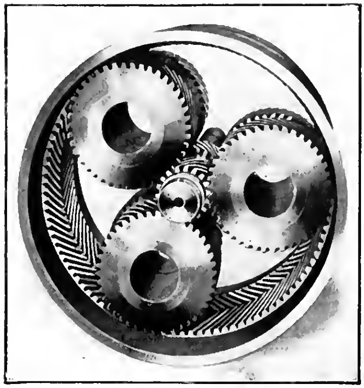


Fig. 1. Turbo-Reduction Gear

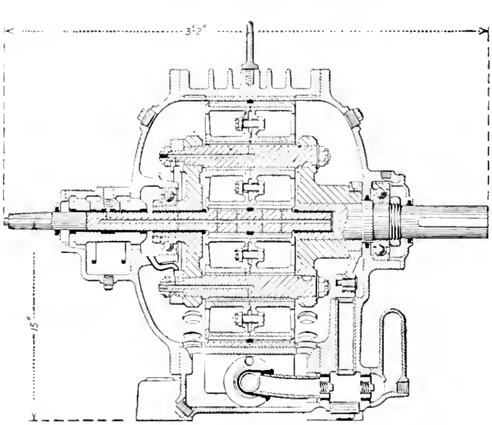
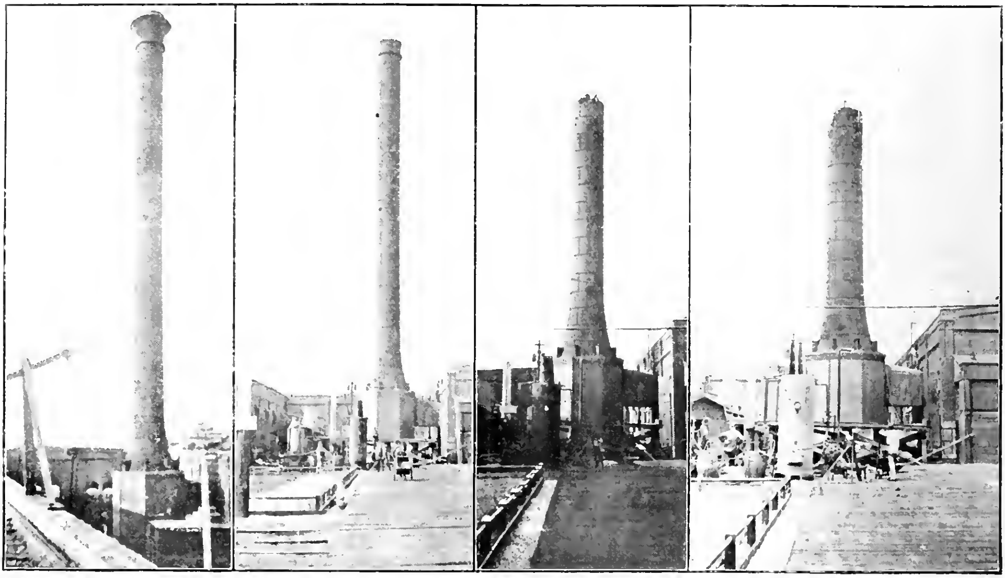


Fig. 2. Section through the Turbo-Reduction Gear

pinion. The high-speed bearings, besides having forced-feed lubrication, are provided with oil rings and an oil reservoir for emergency use. The superfluous oil from the high-speed bearings is collected by a centrifugal oil ring and forced through the hollow shafts carrying the intermediate gears, flushing their bearings. The oil, after lubricating the bearings and gears, is immediately drained to the main oil reservoir in the base of the housing; here it is strained, cooled, returned to the pump and used over again.

Cutting Down a Steel Stack

On Apr. 20, 1915, the St. Louis & San Francisco R.R. began removing the smoke-stack at its North Springfield shops. This stack was 146 ft. high, 8 ft. in diameter and composed of sheets $\frac{7}{16}$ to $\frac{5}{16}$ in. thick. Seventeen rings were removed, the height of each being 56 in.



Removing a Steel Stack with the Oxyacetylene Torch

Oxyacetylene was used in cutting down this stack, says E. W. Allen in the *American Machinist*, at a cost of $283.73 for gas and labor. On account of the condition of the stack, it would have cost approximately $500, if any other method had been employed and would have taken 17½ days to remove it. By using oxyacetylene it was removed with a saving of about $216, and the work completed in six days.

Ingersoll-Rand High Efficiency Air Compressor

The constant demand for higher efficiency and greater economy and the increasing tendency towards the use of higher steam pressures have led to the development by the Ingersoll-Rand Co., 11 Broadway, New York City, of an improved small steam-driven, high-speed air compressor.

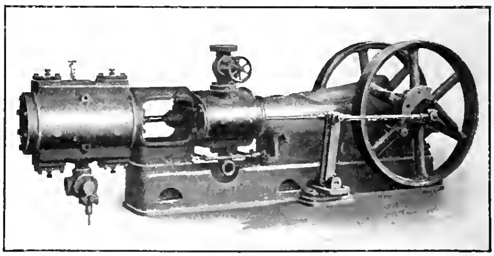
The machine is designed along the same lines as the company's former small steam-driven type, but embodies many improvements which give it a higher efficiency in the air end and a considerably lower steam consumption in the steam end. These improvements are as follows:

The adoption of the Ingersoll-Togler air valves, which allow of high speeds, give high compression efficiency, are almost silent in operation and are independent of any operating mechanism.

Balanced-piston steam valves, designed after the most advanced European practice, permit of high speeds, high steam pressures and the use of superheated steam, at the same time giving a higher efficiency under ordinary low-pressure steam conditions.

An automatic cutoff control gives high steam economy under conditions of varying load or varying steam pressures. This control is regulated by a centrifugal flywheel governor which acts to shorten or lengthen the stroke of the piston valve, thus changing the cutoff.

All wearing parts are copiously and automatically oiled by means of automatic splash lubrication, and inclosed construction and removable covers make for cleanliness with great accessibility.



Steam-Driven Air Compressor

The machine is designed and constructed with special attention to rigidity without excess weight. The bearing surfaces are large and special provision has been made for ready adjustment of all parts, without loss of time.

The automatic cutoff control is supplemented by an air unloader, which assures economy while possessing a high degree of automatism, which is essential in a small compressor designed for severe duty, and generally subject to considerable neglect.

Editorials

Fruits of the Locomotive Boiler Inspection Law

The most cheering part of the paper on "Fruits of the Locomotive Boiler Inspection Law," read before the Western Railway Club by Frank McManamy and published elsewhere in this issue, is that the number of serious locomotive-boiler accidents is decreasing, not because of the application of appurtenances simple or automatic, not because money is being invested in this and that contrivance, but just because the law promotes more thorough maintenance and greater carefulness of operation. Yes, of course, this could have been done without the law. But it was not. And therein lies the chief force of any good boiler-inspection law.

"No railroad man," says Mr. McManamy, "with knowledge of conditions and practices prior to the passage of the law can question the fact that, generally speaking, inspections are now more carefully and more regularly, and repairs more promptly, made, and the question of repairs is less apt to be determined by the number of loads in the yard awaiting movement."

There is just as much morality and altruism in railroad men as in any other class. And it is with due appreciation of these virtues that we remark that the improved conditions mentioned by Mr. McManamy exist because the potential offenders know that they are being watched more closely now than before the passage of the law. The same is true in stationary practice.

Most of us are good anyway, but if we know we are being watched we are better. We admit this to ourselves, but seldom to others.

This looseness or carelessness often manifests itself in acts or conditions that cannot be said to be due to exigencies of the service, or to sacrifice of safety for convenience, or to the erroneous idea of saving money by putting off the day of spending it in needed repairs to parts in dangerous condition. This kind of laxity is detestable, because it is void of reason and inexcusable.

For example, during the last fiscal year the department records show that eighteen persons were injured by studs blowing out of fireboxes or wrapper sheets. Doubtless most of them gave long and ample warning, by leaking, that they needed renewing. It is also true that, usually, they can be renewed more cheaply before blowing out than after. But no, they are tinkered with. They are calked or neglected altogether until finally they blow out.

For this sort of psychological phenomenon no boiler law can of itself do any good. The attitude of mind that allows this condition to continue can be cured only by education, whether it comes by persuasion and reason or is got by the offender-victim being nearly killed before he learns his lesson.

That some opponents of boiler-inspection laws still offer the argument that all boiler explosions are crown-sheet failures, therefore man failures and not preventable through law, is evident from one of Mr. McManamy's statements. Of course such a contention is mere froth. In the locomotive-inspection service during 1914, as compared with 1912, crown-sheet failures decreased forty-eight per cent. and the number killed, sixty-four per cent.

From Mr. McManamy's paper it appears that on some locomotives the location, relative to the highest point of the crown-sheet, of the bottom fittings for gage-glasses constitutes a menace.

It is difficult enough, owing to grades, curves and stops, to keep the crown-sheets of locomotives covered at all times, even where the glasses are conveniently and properly located, and to put them elsewhere is nothing short of criminal. On a busy division particularly, an engineer has so much to watch along the right-of-way that simply a glance from his seat should enable him to see the water level. But we learn that on some types of locomotives the engineer must leave his seat to see the water level, and on others must step back out of reach of the throttle, brake valve and reverse lever to try the gage-cocks. The strongest condemnation of these conditions is too mild.

Happily, the aim of all is to reduce the hazards and attain better conditions generally. And the law is responsible for the movement.

Clean New Steam Lines

In our issue of June 8, on page 785, we printed a letter from E. E. Strong, president of the Strong, Carlisle & Hammond Company, calling attention to the importance of seeing that new steam lines are clear of grease, white lead, iron filings and dirt of all kinds before they are put in use, so that foreign matter may be kept out of separators, reducing valves, steam traps, and all other devices.

The necessity of doing this seems so self-evident that it hardly would appear that comment on the subject was called for, but inasmuch as a man of Mr. Strong's experience has found that carelessness in this particular is common, we feel the importance of calling attention to it on this page, in an effort to do as Mr. Strong suggested—start a campaign of education along the lines of showing the importance of clearing steam lines before they are put in use.

There is a saying somewhat to this effect, although not in exactly the same words, that "the man who would not put dirt in the works of his watch would nevertheless put things into his stomach which are equally bad for that organ." The author of this remark might have gone further and added that the man who takes great pains to keep the brasswork on his engine polished, and other things about his plant neat, will sometimes do just such careless things as to connect up a steam line with lengths of pipe that have lain where they could accumulate dirt and rust in the interior, or that possibly are fouled with chips from threading, without first blowing these lines out with steam before connecting to them anything so susceptible to injury from foreign particles as a separator or a reducing valve or even a steam trap.

Surely this is one of the big little things about a steam plant that the engineer in charge should give his personal attention to, whether the work is being done by outside help or by his own force, so that no pipe connections may be made in such a way that there is any risk of foreign matter getting into the system.

License Committees Take Notice

When the framers of the present New Jersey license law had completed their task, with the assistance of an attorney, no one of the many who looked over the bill could find fault with it. When the license bureau began its work, however, a defect showed itself.

The law states that "provisions of this act shall not be construed to include or apply to" marine engineers, engineers in plants under the jurisdiction of the United States, nor locomotive engineers. They were and are willing to be examined and pay for licenses, but the attorney-general says that they cannot lawfully be granted licenses. They are now aggrieved and protest vigorously.

The import is far more serious than appears on the surface. The wording of the law is such that an engineer holding a license to run a dinky tugboat may operate the largest and most complex stationary plant in the state and be immune from any action that the license bureau may see fit to take.

This is important, and license committees should take a lesson from New Jersey's error.

The Firebrick Problem

Obtaining the investment and operating advantages possible with high boiler ratings has confronted the engineer with high-temperature problems that, while serious, are being admirably met. Procuring the most suitable firebrick for given conditions is only one of these problems, but it is so far the one furthest from a satisfactory solution.

The engineer may, after tests and experience, select the most suitable of available bricks, but it is the manufacturer's function to produce bricks that will meet the extremely high temperatures associated with modern boiler-room practice. When a boiler is operating at from two hundred to three hundred and fifty per cent. of rating, the furnace is filled with a dazzling white gas and the temperature approaches three thousand degrees Fahrenheit. This is within a few hundred degrees of the temperature at which pure fireclay will melt.

With the widely fluctuating furnace temperature, the bricks are subjected to severe expansion and contraction. Arches frequently have extremely high temperatures on one side and comparatively cool gases on the other; side walls are affected by the chemical action of the fusing ash; and poor clay, when between joints, soon drops out, exposing the brick to a soaking-in heat. And so it goes, the sources of trouble being numerous, and greatly increased if the masonwork is not of the best.

Notwithstanding the seriousness of the firebrick problem, it is a fact that little really useful information relative to it has been published. The article elsewhere in this issue is one of the best general ones that has come to our attention. It is replete with information that any engineer can use, whether he operates at a high or a low rating, or a large or a small boiler plant.

But it is not enough. There are many plants where the firebrick problem has been, and is now being, investigated and the need for immediate dissemination of results is urgent. Those who have investigated extensively and discovered and compiled truly useful and applicable information should give others the benefit by making it available for publication.

Does the Amended Massachusetts Law Discriminate?

We have just received a communication which brands as discriminative the Massachusetts license law as amended. As told editorially in our issue of June fifteenth, the law was amended to allow plants operating the major part of the time by water to be in charge of an engineer holding a special license. The writer of the letter wishes to know why plants having waterwheels should be so favored, while the same liberties are not extended to plants run by electric motors, driven by purchased current the major part of the time.

If the danger is no greater in one case than in the other, then there is no reason why the plant operated most of the time by electric motors, but only part of the time by its own high-pressure-steam-driven machinery, should not be allowed to be operated by a man holding a special license. Where none of the engines and boilers in such a plant is not of greater capacity than one-hundred and fifty horsepower, a special license will cover the plant. But if any of the engines or boilers are of greater capacity a first-class engineer must be in charge, though the plant is driven most of the time by purchased current.

Technically, it is easy to show that the amended law is discriminative in favor of water power, but plants operating on purchased current most of the time and running their own engines and boilers some of the time are few. The condition rarely exists, because when an industrial plant uses purchased current it uses it exclusively or only on overloads, which are carried by new equipment just as soon as the latter can be advantageously installed. Of course, breakdown service is available in some plants, but, as its name implies, it is only for emergencies.

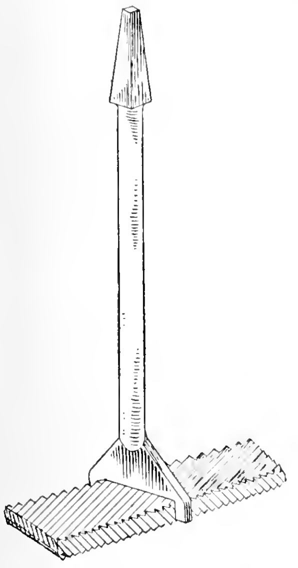
It is not at all likely that serious trouble will follow the discovery of this technical discrimination, because there are few, if any, such plants in existence to be discriminated against. In plants such as our correspondent has in mind, the owner will find it good business to keep a thoroughly competent man in charge, regardless of what the law allows him to do. The law will allow you to take your watch to a blacksmith for repair, or get your hair cut by a gardener who trims the hedge, but you would not take advantage of either opportunity.

Efforts are being made before the New York Constitutional Convention to have the Public Service Commissions made constitutional bodies surrounded with all the safeguards afforded the courts. There are few departments in the state government wherein personal integrity and moral courage count for more, and any step that will help to render the public service commissions free from personal or political influence is commendable.

Correspondence

To Smooth a Valve Seat

A 1-in. globe valve, although nearly new, gave trouble by leaking. It was in a rather dark corner, so for a long time it was not noticed that the valve seat had become roughened from some cause. When discovered, the first thought was that a new valve would be necessary, as we had no tools at hand for dressing the seat, but a piece of flat file short enough to be turned around while lying flat on the seat did the work. A contrivance for rotating the file was made from the shank of an old wood bit, flattened and shaped as shown in the illustration. With this tool in a common bit brace, the valve seat was quickly made as smooth as when new.



VALVE SEAT SMOOTHING TOOL

G. E. MILES.

Denver, Colo.

Engineer Killed in Peculiar Turbine Accident

About the middle of last month a turbine connected to a 250-kw. generator in a cold-storage plant in New York City wrecked itself and instantly killed the engineer in charge. The cause of the accident is not definitely known nor the circumstances leading up to it, as the engineer was alone in the room at the time. From indications, however, it is believed that the bearing-cap on the end of the shaft next to the rotor had become loosened and that the engineer was tightening or adjusting it at the time. The shaft was 1⅝ in. diameter and ran at 9000 r.p.m. It was impossible to tell from the wreckage whether it was the shaft or the bearing which gave way first, as both were badly broken up.

The duty of this set was particularly severe, as there was no duplicate machine and it was kept in constant operation, except a stop of half an hour on Sundays, so that most of the adjustments which were made had to be done while the machine was in service. This accident demonstrates anew the extreme risk to man and machinery of making even minor adjustments not intended to be made while the machine is in motion, and especially so when operated at such high speed.

WILLIAM SOUTHARD.

New York City.

Notes on Alternating- and Direct-Current Motors

In the May 4 issue under the caption, "Interior Wiring for Lighting and Power Service," Mr. Cook makes some statements that are not quite up to the latest practice. First, in reference to the voltage employed by alternating-current motors, he states that in some cases for very large motors 2200 volts is used. Now 2200 volts is commonly used and 6600 and 7500 volts are occasionally used for large motors. Probably the most notable 6600-volt induction-motor installation is the three 6000-hp. machine group in the rail-mill department of the steel works of the U. S. Steel Corporation, at Gary, Ind. A description of these motors was published in POWER in the issue of Apr. 5, 1910. In a recent steel-mill installation 6600-volt induction motors have been used throughout; the machines ranging in size from 350 to 3000 hp. and aggregating approximately 12,000 hp.

Another important installation is the 300-hp., 7500-volt induction motors used to drive the exciters in the new power house of the United Electric Light & Power Co., New York City.

If we include synchronous condensers and frequency changers in this category, it will be found that the voltage is even higher, as there are a number of 11,000- and 13,200-volt synchronous motors in operation in this country; probably the highest-voltage machine of this type being the 16,500-volt, 6000-kv.-a. synchronous condenser used for power-factor correction by the Southern California Edison Co., of Los Angeles. What in all likelihood is the largest frequency changing set in service today is that installed to interconnect the Boston Elevated and Boston Edison systems. This set consists of a 13,200-volt, 25-cycle unit rated at 9000 kv.-a., and a 13,800-volt unit rated at 9000 kv.-a.,

Secondly, with direct-current systems it is possible to obtain motors that will allow a speed change of 3 to 1. One of the latest productions of the electrical industry is an adjustable-speed reversible direct-current motor for metal planers and slotters, having a speed range of 250 to 1000 r.p.m. by field control; these machines have been standardized up to 50 hp. Motors for continuous service, with a speed range of 1 to 4, have been built in sizes up to 125 hp., and 225-hp., 500-volt machines with a speed range of 225 to 675 r.p.m., or 1 to 3. Moreover, 115-230-volt machines may be had with a speed range of 1 to 6 in sizes up to 25 hp. continuous-service rating, or 15 hp. intermittent-service rating.

Thirdly, Mr. Cook appears to use the terms "adjustable-speed" and "variable-speed" alternating-current motors synonymously, whereas they mean two different types. The variable-speed machine is one in which the speed is constant for constant load, but varies with the load, accelerating with light loads and dropping again when the load comes on, as in a direct-current motor with armature control or a phase-wound rotor polyphase induction motor with rheostatic control. Adjustable-speed machines are those in which the speed remains approximately constant at any adjustment, irrespective of the load. One of the best examples of this type is the direct-current shunt motor with field control. Until recent years only direct-current motors were available for strictly adjustable-speed drives, which is also true today for small motors where wide ranges of speed are required. However, during the past eight or ten years schemes have been developed for adjusting the speed of alternating-current motors, so that now the adjustable-speed polyphase induction motor in many cases compares favorably with the direct-current machine, especially in large units for rolling-mill drives, mine fans, etc., and in some cases it shows an advantage over the direct-current machine. For example, in 1913 a 600-hp., 2200-volt adjustable-speed polyphase induction-motor set for driving a rolling-mill was installed, having six different synchronous speed adjustments between the limits of 300 and 500 r.p.m. This set consists of two machines arranged so that they can be connected in cascade. The primary motor has a phase-wound rotor with its stator wound for 14 and 16 poles; the secondary motor is a squirrel-cage machine having its stator winding arranged so that it can be grouped for 4- or 8-pole connections. It is worthy of note that this set was chosen in preference to a direct-current machine, and that it has proved very satisfactory in service.

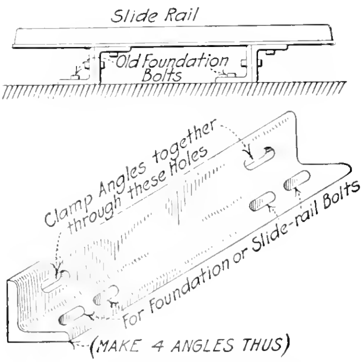
A. A. Fredericks.

New York City.

Realigning a Belt-Driven Generator

The illustration shows a method I used in realigning a belt-driven exciter so the belt would not slip off under heavy load.

The material required consists of four pieces of angle iron selected in proportion to the size of the machine. The combination of lateral and transverse slots gives freedom of motion to square up the machine. For ordinary aligning four symmetrical angles will do. However, should a machine have to be shifted endwise considerably, slots can be cut in the foundation angle bars.



Material for Mounting Generator

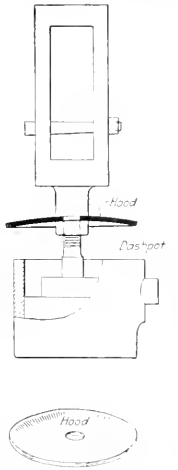
Fred E. Walchli.

Kalispell, Mont.

Hood over Dash Pot

We had considerable trouble in keeping the latch blocks and plates in good condition and the cutoff equalized on a Brown twin-engine. It was impossible to maintain an equal cutoff or equal distribution of the load between the two sides.

The valve-stem stuffing-boxes being very shallow, it is difficult to prevent some leakage, and most of the time there is more or less water dripping into the dashpots. A sort of drip cup is provided under the stuffing-boxes, intended to catch and carry off the leakage, but it is of little value. It is desirable to keep water away from the valve gear because it washes off the oil, but there is no room to put a shield where it will do the most good. I therefore arranged a sheet-metal hood over each dashpot, as shown in the illustration. Previous to this we were tinkering with latch blocks and plates and adjustments continually, but now the engine runs for months without requiring more than slight adjustments to the valve gear.



Hood in Place

H. L. Strong.

Yarmouthville, Maine.

Reversed Field Coils

The terminals of some field coils are so located that if the coil has been turned over or turned end for end while installing, the appearance of the terminals makes the mistake evident. There are coils, however, which may be inverted without the appearance of the terminals suggesting any irregular condition. The terminals of such coils are located in the centers of opposite sides or of opposite ends, and the coil appears the same irrespective of the manner in which it may have been installed. Any such mistake which results in the current circulating in the wrong direction will reverse the polarity of the coil, and if the number of reversed coils is a sufficiently large proportion of the total number, the machine will be unable to build up its field. At all events, the voltage obtainable will be reduced and commutation will be impaired.

An inspector was called to locate the trouble in a generator that was unable to build up its field; even when the machine was separately excited from another, the value of the voltage obtainable was very small. The machine had been in a flood and had been disassembled for cleaning. The operator stated that he had marked the field spools when removing them and that he had replaced them just as they had been marked. He evidently either had marked the spools incorrectly or had failed to observe the marks carefully while reassembling, because on raising the brushes, exciting the field from another machine and testing the polarity with a nail, all the bottom poles were found to be of the same polarity.

The terminals of the field coils were in the centers of opposite ends of the coils and two alternate coils had been installed end for end, thereby reversing two coils out of five and making five consecutive similar poles. An inspection of the direction arrows stamped on the flanges of the field spools confirmed the supposition.

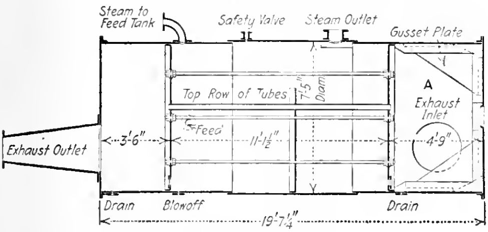
Where the marks on the flanges are not plain or where there is any doubt as to how a coil should be placed, the best plan is to temporarily place and connect the coil and test the polarity with a nail or compass. Where a compass is used by an inexperienced person, it is best that the test be made with the armature withdrawn; otherwise, the poles induced in the armature core by the polepieces may cause misleading results.

E. C. Parham.

Schenectady, N. Y.

Exhaust-Gas Heated Boiler

In one of the power houses of a large engineering works where gas made from bituminous coal supplied the motive power, the heat from the engine exhaust was utilized to generate the steam supplied to the gas producers. The plant was run with the ammonia-recovery process, thus requiring 1 to 1.25 lb. of steam for every pound of coal



Section through Boiler

used. Three 1000-hp. engines and exhaust boilers were to be installed, although only one unit was at first put in.

The exhaust pipe was 30 in. in diameter and had two gate valves arranged so that the gases could be led either to the boiler, from which they entered a large masonry chamber, or silencer, built in the ground, or they could travel directly to the silencer.

The sketch shows the boiler, which evaporates 2.5 lb. of water at 100 lb. per sq.in. per brake horsepower delivered by the engine. It was of horizontal cylindrical construction, 19 ft. 7¼ in. in length and 7 ft. 5 in. least internal diameter, the sides being ½-in. plate and the ends of ⅝-in. plate; the tube-sheets were ¾ in. There were 182 tubes, 3¼-in. outside diameter at 4½-in. pitch, giving over 1700 sq.ft. of heating surface. The tube sheets were stayed by seven 1½-in. stays, and midway the tubes were supported by a plate cut out at intervals around the circumference to permit of freer circulation of the water.

The exhaust gases entered the firebrick-lined compartment shown and, after passing through the tubes, entered a 3½-ft. compartment, also supplied with a manhole and drain, and then through a 30x18-in. reducer to the silencer. The working level of the water was about 4 in. above the top row of tubes.

The boiler was fitted with the usual safety valve, manhole, steam and water gages, a 3-in. steam connection for heating the feed-water tank, a 3-in. feed inlet, a blowoff valve and mudholes, and was connected to the gas producers by an 8-in. steam line. Below the steam opening in the boiler was a ⅛-in. copper plate clearing the opening by 2¾ in., for preventing priming. The heating surface of the tubes was 1723 sq.ft.

G. Moore.

Newark, N. J.

An Emergency Gasket

The lead gasket illustrated and described by F. W. Reynolds in the issue of May 25, on page 725, has been used with fair success under different conditions for many years. A light piece of lead pipe is often employed for the same purpose. Such a gasket may be improved by drawing into the pipe a piece of asbestos rope to act as an equalizing cushion.

James E. Noble.

Toronto, Ont.

Wrong Stator Connections

If the stator coils of a three-phase induction motor are delta-connected, each will be subjected to the full line voltage; if Y-connected, however, each pair of line wires will include two stator coils in series, in which case the voltage per coil will be approximately 0.58 of the line voltage. Moreover, in a Y-connected stator the current of the line and of each coil is the same, whereas with the delta connection the line current divides between two paths. The operating characteristics of the motor will vary accordingly as one or the other of these connections is used, because the resistances and reactances involved differ in the two cases.

For several years a three-phase induction motor had successfully driven the compressor used for storing with compressed air the whistle-blowing reservoir of a fire-alarm system. Owing to continuous neglect of the automatic governor, abnormal pressures obtained at times, with the final result that the stator burned out. It was rewound, after which, firemen in the outlying districts began to miss fires and invariably gave the excuse that they had not heard the whistle. Repeated trials proved the excuse to be well-grounded; the whistle was inaudible in districts where it could be plainly heard, even if an opposing wind were blowing, before the stator was rewound.

Investigation disclosed that the motor was heating abnormally and that it could store against only 60 lb. pressure, whereas it formerly had been able to store at 100 lb. without any distress. Checking of the rotor speed showed the slip at 60 lb. to be 240 r.p.m. On a normal motor the slip would not have exceeded 60 r.p.m. The end shield was then removed and the connections inspected, and it was found that the coils which were bought for the rewinding were greater in number and had smaller wire than those of the original winding. The repairman had installed the new coils in the same manner as he had found the old ones, and in the absence of instructions he was justified in doing so. The original coils were Y-connected and the new ones were also, but they should have been delta-connected.

J. A. HORTON.

Schenectady, N. Y.

A Mistaken Notion

I observed an engineer carefully pointing a pine plug to drive in as a substitute for a pump-cylinder cock that was lost. Inquiry developed that he believed the steam would have less chance to blow the pointed plug out than if the end was blunt.

Since then I have heard others pull off the same line of argument. It is true, of course, that if steam or water is issuing with considerable force a pointed plug may be more easily entered, but that is "another story." I hope I will not be classed as a "plug fitter" by reason of the foregoing observations.

A. E. BAKER.

Cambridge, Ohio.

Indicator Showed Leaking Piston

Diagrams taken from a 9x16x24-in. Corliss engine with the low-pressure cylinder disconnected for experimental work showed a peculiar back-pressure line. The

FIG. 1. DIAGRAM INDICATES LEAKAGE

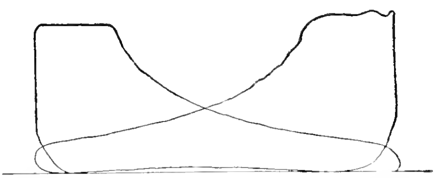


FIG. 2. CONDITION AFTER INCREASING TENSION

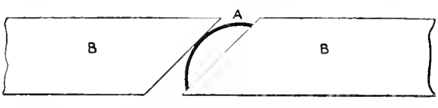


FIG. 3. STEEL SPRING TO GIVE TENSION TO RING

hump in the exhaust line, shown in Fig. 1, would appear on the head end for a day or so, then show up on the crank end for a few days, and then back to the head end again, owing to some change in the position of the piston ring.

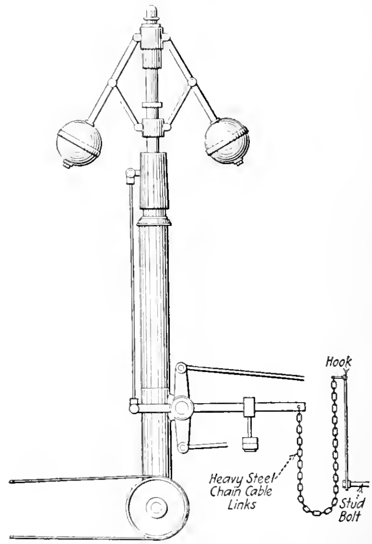
A piece of heavy clock-spring was filed and peened to fit, as shown at *A*, Fig. 3, and just long enough not to bind when the ring was compressed. The joint was open about $\frac{3}{16}$ of an inch when compressed to the cylinder size, allowing sufficient clearance for the spring. Before inserting the piston in the cylinder the joint of the ring was turned to the top of the piston to prevent spring *A* working loose and cutting the cylinder. Other diagrams were taken after this change, with results as shown in Fig. 2.

WILLIAM SMITH.

Union Hill, N. J.

Corliss Governor Compensator

The accompanying illustration shows a chain compensator for a Corliss engine governor. The chain has all of the advantages of a gag pot, and in addition the governor will take hold quicker in bringing an engine up to speed when starting up than if a gag pot is used.



CHAIN COMPENSATOR FOR A CORLISS ENGINE GOVERNOR

When the governor balls are in their lowest position the major part of the chain pulls down on the lever, and when the balls are in their highest position the major part of the chain is supported by the standard.

C. E. BASCOM

Westfield, Mass.

Storm Demolished Two Stacks

On the night of May 27, a storm blew down the two 30-in. x 75-ft. smoke-stacks of the Moberly artificial ice plant at Moberly, Mo. Only one boiler was in use at the time, and, strangely, the $1\frac{1}{4}$-in. water-column pipe was torn out from that boiler, blowing all the water out. The stack fell in such a way that it did not damage the building or equipment except as stated.

C. F. DOEHRING.

Moberly, Mo.

Inquiries of General Interest

Weight of Spanish Libra—What is the relation between the weight of the Spanish pound used in Latin-American countries and the avoirdupois pound of the United States?

P. P. C.

The Spanish "pound," or more properly "libra," is equal to 1.0161 United States avoirdupois pounds, or 1 lb., 0.2676 oz.

Capacity of Pump—What is the capacity, in gallons per minute, of a duplex steam pump with water cylinders 6 in. diameter, when running at a piston speed of 90 ft. per min.?

E. P.

Without allowing for reduction by presence of the piston rod, the piston displacement in each water cylinder would be

$$(6 \times 6 \times 0.7854) \times 90 \times 12 = 30{,}536.35 \text{ cu.in. per min.}$$

and, without allowance for slippage, the combined pumpage of two water cylinders would be

$$(2 \times 30{,}536) \div 231 \text{ cu.in. per gal.} = 264.4 \text{ gal. per min.}$$

and, allowing 5 per cent. slippage, the delivery would be

$$264.4 \times 0.95 = 251.18 \text{ gal. per min.}$$

Factor of Evaporation with Superheated Steam—What would be the factor of evaporation in the generation of steam at 135 lb. gage pressure with 100 deg. of superheat, from feed water at 200 deg. F.?

R. J. F.

A gage pressure of 135 lb. per sq.in. would be equivalent to about 150 lb. absolute, and by reference to Marks and Davis' Steam Tables it is found that a pound of steam at 150 lb. absolute, when superheated 100 deg. F., contains 1249.6 B.t.u. above 32 deg. As the latent heat of steam at 212 deg. F. is 970.4, then, as compared with evaporation from and at 212 deg. F., the factor of evaporation would be

$$\frac{1249.6 - (200 - 32)}{970.4} = 1.1146$$

Testing Flow of Steam—How can a test be made of the weight of steam used by a small steam pump?

W. L. B.

If one of the several types of steam meters is not available, a close approximation to the rate of flow can be determined for a stated pump speed and other operating conditions by placing a gaging stop valve in the steam line to the pump and ascertaining the flow that takes place through such a valve under the same conditions of valve opening and pressure on each side of the valve as when the pump is in operation. For the purpose, place a pressure gage on each side of the valve and, with the gaging valve partly closed, observe the indication of each pressure gage while the pump is in operation. Then, with the pump shut down, determine, by increase of weight, the rate at which the steam condenses when discharging without loss into about three-fourths of a barrel of water, having the same opening of the gaging valve and same readings of the pressure gages as when the pump was in use. The pressure on the discharge side of the stop valve can be regulated by throttling the escape of steam to the condensing water.

Relative Economy with Different Initial Pressures—What would be the relative economy of employing steam at an initial pressure of 75 lb. and at 100-lb. gage pressure per sq.in., if in each instance the clearance is 5 per cent., cutoff at ¼ of the stroke, the average back-pressure 4 lb. gage and the boiler-feed water 200 deg. F.?

G. K.

By referring to a table of mean pressures per pound of initial pressure with different clearances and points of cutoff (such as given on page 115 of Low's "Steam Engine Indicator"), it may be seen that with cutoff at ¼ stroke and 5 per cent. clearance, the mean pressure per pound initial absolute would be 0.6258 lb. Therefore, with an initial pressure of 75 lb. gage, which is equal to about 75 + 15, or 90, lb. absolute, and back-pressure of 4 lb. gage, or 4 + 15 = 19 lb. absolute, the mean effective pressure would be

$$(90 \times 0.6258) - 19 = 37.322,$$

and with an initial pressure of 100 lb. gage, or 115 lb. absolute, and the same average back-pressure, the mean effective pressure would be

$$(115 \times 0.6258) - 19 = 52.967 \text{ lb.}$$

As the density of steam at 90 lb. absolute is 0.2044 lb. per cu.ft., and of steam at 115 lb. absolute is 0.2577 lb. per cu.ft., then for the same cutoff and same diagram factors the relative weight of steam required per pound m.e.p. would be as

$$\frac{0.2044}{37.322} \text{ to } \frac{0.2577}{52.967}, \text{ or as } 1.1256 \text{ to } 1.$$

For comparison of cost, it may be assumed that in each instance steam is generated from a feed-water temperature of 200 deg. F. A pound (wt.) of steam at 90 lb. per sq.in. absolute contains 1184.4 B.t.u. above 32 deg. F., hence each pound raised from feed water at 200 deg. F. would require

$$1184.4 - (200 - 32) = 1016.4 \text{ B.t.u.}$$

while a pound (wt.) of steam at 115 lb. per sq.in. absolute contains 1188.8 B.t.u. above 32 deg. F., and each pound raised from the same temperature of feed water would require

$$1188.8 - (200 - 32) = 1020.8 \text{ B.t.u.}$$

Therefore, the cost of steam required per lb. m.e.p. or per hp., employing 75 lb. boiler pressure, would be to the cost employing steam at 100 lb. boiler pressure as

$$1.1256 \times 1016.4 \text{ to } 1 \times 1020.8, \text{ or as } 1.1207 \text{ to } 1.$$

Action of Bourdon Gage Tube—What causes the tube of an ordinary Bourdon spring pressure gage to become straighter for an increase of pressure?

J. R.

As the tube is curved and flattened at right angles to the plane of curvature, when inflated there is a tendency for it to assume a circular form of cross-section, giving rise to tensile stress in the tube material which forms the outside of the curve and compressive stress in the material forming the inside of the curve.

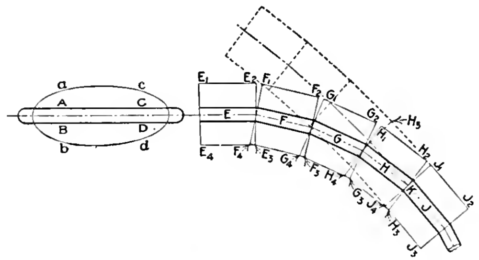


Diagram Illustrating Action of Gage Tube

The action is the same as though the curved tube was composed, as shown in the figure, of a number of straight tubes of cross-section like ACDB joined together in polygonal form EFGHJ. Such sections, when independently inflated to the oval form of cross-section acdb, would be represented by the trapezoids $E_1E_2E_3E_4$, $F_1F_2F_3F_4$, etc. But, as shown by the figure, when the sections are thus separately inflated, they would separate along the outer, or convex, side as at H_2KJ_1 and would be compressed together along the inner, or concave, side of the tube as indicated by the overlapping J_4KH_3. Hence, after inflation of the sections, when a section like H remains continuous with an adjacent section like J, the latter being held stationary, then for H_2 to remain in contact with J_1 and for H_3 to remain at J_4, the inflated section H would have to assume the position $H_5J_1J_4$. Like movement of the consecutive sections would result in a change in their alignment to that indicated by the dotted lines, and the action of straightening out from inflation would be similar if the original sections were short enough to form a continuous curve of flattened tubing, such as used in the Bourdon spring pressure gage.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—EDITOR.]

Testing Central-Station Heating Mains

During the last heating season, engineers of the Merchants' Heat & Light Co., Indianapolis, Ind., have been making tests to determine whether any part of the central hot-water heating system in that city needed renewal. The tests were also designed to discover the location of any overloaded section of the piping system. The procedure of the tests was as follows: Observers were stationed at the plant, at the end of the main trunk line about 800 ft. from the plant, and at the end of laterals about 3000 ft. from the trunk line. With these watchers in readiness and with constant pressure maintained on the system, the fires under the circulating boilers were dropped simultaneously at a prearranged time. Immediately afterward the fires were forced skillfully to bring the water temperature back to normal. The various observers took simultaneous time and temperature readings, noted the fall in temperature as the cooler water passed their respective stations and also the time that elapsed before the temperature was restored to normal. With these data and with the distance between stations known, a few simple calculations gave the speed of the water in the mains and the line losses in deg. F. occurring between the power plant and the point of reading. The results were plotted with time as ordinates and temperature as abscissas. The curve produced clearly showed the passage of the cooler water by a dip in an otherwise comparatively straight line. Near the station the readings showed the dip to be very pronounced. Further out on the system it became more shallow. These dips gave an indication of the relative line losses in the main and laterals, while the velocity of the water was taken as the most definite indication of the loaded conditions of the pipe, high velocity indicating heavy loading, low velocity, light loading. Considering velocities of 4 ft. per sec. in mains and 3 ft. per sec. in laterals as the maxima allowable, the test data show conclusively that almost the entire system is in good operating condition, although the lines were laid fourteen years ago, and according to some theories of depreciation, should now be ready for replacement.

Readings were also taken on all lines to determine the difference between the flow and the return pressure. These data will be of value in considering future loading of the lines, because in general customers should not be added to a line with a differential pressure of less than 1 lb. per sq.in.—"Electrical World."

Encouraging Water-Power Development in Washington

Through its Extension Division, the University of Washington, Seattle, has adopted an interesting plan to encourage the active development of local water power, affording free expert advice for proper and effective installations at available properties. In this, the primary purpose is to assist individual owners of water sites who might be unable at the moment to employ experienced engineering talent, as well as small rural communities similarly situated, inspiring active interest in the possibilities presented.

The inauguration of this department has led to considerable activity along coöperative lines. Owners have been supplied with information applicable to service, in a consistent, economical and profitable way. In some cases recommendations to employ consulting engineers have been made, it being the particular province of the university to suggest the most feasible plan, with all essential data, rather than carry the proposed project to completion.

In explanation of this new public consulting department, the university calls to notice that hundreds of small water powers are still undeveloped in the state. Many farms and country homes are so situated that electric power for lighting and cooking could be secured at a very reasonable cost, while in some cases, heating by electricity is possible at an economical figure. Investigations show that a large proportion of the small water powers are worthy of the utmost development. Owners do not always know the value of their sites and on such uncertainty cannot afford to employ an engineer capable of giving the necessary advice; on the other hand the engineer cannot afford to give his services free.

As regards the working of the plan, the University of Washington, being a state institution, is in a position to lend assistance by sending an expert to report on the advisability of development. If no extended surveys are required, this engineer will suggest a proper method of procedure and probably make some little sketch to be followed in the construction. Should surveys be necessary and the expense is justified, it will be so reported and the owner asked to secure some private engineer to make them, provided the owner wishes it done at his expense. No charge is made for the information or technical advice given out by the university engineer, excepting his necessary traveling expenses, which must be borne by the person asking his services.

Convention of American Boiler Manufacturers

The twenty-seventh annual convention of the American Boiler Manufacturers' Association, held at the Hotel Lawrence, Erie, Penn., was called to order by the president, W. C. Connelly, on June 21, with 108 manufacturers' representatives present. The report of the committee on uniform boiler laws recited the efforts which had culminated in the A. S. M. E. code. Thomas E. Durban, chairman of the committee, said that the industrial commissions of Pennsylvania and Wisconsin had already adopted the code. He was assured that California, Chicago and St. Louis would adopt, and that the conservative Master Boiler Builders' Association had already approved the code. N. A. Baumhart, chairman of the Ohio Board of Boiler Rules, told the convention that the Ohio rules would be amended to include the A. S. M. E. code. John A. Stevens, chairman of the A. S. M. E. committee that formulated the code, urged its promulgation on behalf of the consulting engineer.

C. H. Wirmel, formerly head of the Ohio Boiler Inspection Department and chairman of the N. A. S. E. committee on legislation, invited the attendance of those interested in the general adoption of the code at the N. A. S. E. convention to be held at Columbus, Ohio, in September. John T. McCabe, boiler inspector of Detroit, approved the code, but held that the city or state could only prescribe absolute essentials, and even then the burden of proof rests on the inspector. He also announced that he would pass A. S. M. E. boilers wherever made. Dr. C. L. Huston stated that "two dollars per ton" was not the only difference between furnace and flange steel. The firebox plates, which are stressed by unequal temperatures, required more rigid inspection. The steel used should be openhearth selected from the middle of the run, and there should be closer supervision of the entire process. Mr. Lynch, representing the Association of Steel Manufacturers, testified to its approval of the code, which was a credit to Messrs. Stevens and Durban. H. P. Goodling, speaking for the portable-engine interests, said the principal objections to the enforcement of the code would be the inspection and license requirements. The attempt to adopt such measures in Florida had been frustrated because the small operators were afraid they would have to employ licensed men. Michael Fogarty, a delegate to the New York Constitutional Convention, said that a boiler law must be passed before the code could be adopted. At his request the convention adopted a resolution indorsing a proposed constitutional amendment. A copy of the resolution was sent to the Hon. Herbert Parsons, chairman of the committee on industrial relations of the New York Constitutional Convention. T. W. Herendeen, secretary of the National Boiler and Radiator Manufacturers' Association, expressed his association's approval of the code and pledged coöperation in securing its general adoption. G. S. Barnum, of the Bigelow Boiler Works, told of a rumor that a law or rule might be passed admitting code boilers to Massachusetts. T. M. Rees, of Pittsburgh, belatedly protested against the adoption of the code. He especially objected to its condemnation of lever safety valves and lap joints, quoting "Power" to show butt-strap joints were not immune from cracks. The convention voted to refer his objections to the committee on A. S. M. E. boiler code. C. V. Kellogg, president of the National Tubular Boiler Makers' Association, told of its activities and expressed sympathy with the A. S. M. E.'s efforts to promulgate the boiler code.

President Connelly recommended for consideration: The adoption of uniform specifications covering material guarantees, workmanship and methods of payment; ways and means to secure universal adoption of the A. S. M. E. code; the securing of laws whereby boilers approved by authorities in one state should be recognized as good in all states; the action of water-tube boiler manufacturers in guaranteeing boilers for 200-per cent. capacity, thus cutting the market for boilers in half.

The convention decided to form an administrative council consisting of one member each from the American Boiler Manufacturers' Association and from other allied organizations. This council will conduct a campaign for the adoption of the boiler code, the campaign expenses to be prorated among the interests represented, to the amount of $12,000 a year. A model inspection and license law was referred to this council to be modified and adapted to conditions in various parts of the country. H. D. Mackinnon presented a report of the committee on uniform cost system. The convention adopted suitable resolutions on the deaths of Past-President E. D. Meier and Past-Treasurer Joseph F. Wrangler. The following officers were elected: President, W. C. Connelly (reëlected); first vice-president, C. V. Kellogg; second vice-president, G. F. Barnum; third vice-president, E. C. Fisher; fourth vice-president, Isaac Harter, Jr.; fifth vice-president, Charles F. Hooper; secretary, J. D. Farasey; treasurer, H. N. Covell; representative on administrative council, E. R. Fish. Past-Presidents Richard Hammond and Henry J. Hartley were elected honorary members. Fifteen firms joined the association during the past year, making 87 companies and 15 associate members enrolled. Six of the fifty charter members were present at the convention. The convention passed a vote thanking the Erie City Iron Works, Union Iron Works, Burke Electric Co., and the visitors that had contributed to the discussion and the committee work. The business sessions concluded with a banquet at the Hotel Lawrence on the evening of June 22.

Future Developments in Heating and Ventilation*

By A. H. Barker

SYNOPSIS—The author discusses the general nature of unsolved heating and ventilation problems and outlines some interesting experimental work now being conducted at the University College.

The twin sciences of heating and ventilating have more unexplored problems and greater difficulties attending their solution than almost any other branch of engineering. This is due to the immense complexity of the two sciences, the difficulty of defining in exact terms the results to be expected and the fact that the criterion of success has of necessity been the feelings of individuals rather than the readings of scientific instruments. In addition, the immense power of adaptability of the human organism tends to make actual variations of conditions appear unimportant in practice. In this branch the first obstacle is the great difficulty of finding the facts.

Consider, for instance, the first problem for an engineer endeavoring, without previous experience, to arrange a satisfactory scheme for ventilating a building. He would begin with the assumption that the artificial ventilation of a building consists of forcing in a calculated volume of air. If he were familiar with fans and the laws of the flow of air in ducts, he might think the task easily accomplished. But after he had once tried to satisfy the occupants of the building, he would find the distribution of air currents a problem of great difficulty even in a small building. Although each of these currents obeys rigidly accurate laws of nature, as a whole they are so complex that their expression as terms of exact science is almost impossible. Complaints of the ventilation of almost every public room are heard, but should the ventilating engineer be held responsible when no one can specify what is wrong or what is needed to put it right?

The arrangement of a satisfactory heating system is no less complex. Heat is delivered into the room by convection currents of heated air and by radiant energy. These forms of heat are quite different from each other, yet they can be instantaneously transformed from one to the other and back again. Their measurement, again, is not a problem to be easily solved. The mere act of measuring the amount of radiant energy turns all or part of it into convected heat.

The most baffling difficulty, however, in the attempt to reduce this subject to an ordered science is that the object of both heating and ventilating, though primarily physiological, is also to some extent psychological. The primary object is to keep the inhabited rooms healthful; to keep them comfortable is of almost equal importance. The effect of any given condition on the human body is, if possible, more complicated than the laws which govern air currents and heat flow. The author believes that in the interests of health the temperature maintained should he as low as can be endured without real discomfort. Yet others will say that the room should be so warm that the occupants feel comfortable without any effort. No one can tell us within 300 per cent. how much fresh air per head per hour is the minimum consistent with health. A room filled with air absolutely pure, so far as chemical analysis can detect, may feel very stuffy. For instance, in the House of Commons the air is, chemically speaking, as pure as in any room in the world. No less than 13,000 cu.ft. of air is supplied per head per hour, yet it produces the effects associated with defective ventilation—lassitude, sleepiness, and infection. A room may, on the contrary, feel fresh and sweet when, judged by chemical standards, the air is very bad. The author has analyzed air containing 25 volumes per 10,000 of CO_2, which felt as fresh as a spring morning, although 10 volumes is regarded as the extreme allowable impurity.

The future of heating and ventilating depends, on the scientific side, upon the further analysis of the conditions that produce the feeling of comfort and other effects. This half of the problem is for the psychologist. The attempt to specify healthful and comfortable conditions involves experiments, that in essence are attempts to calibrate human beings.

The practical side of the problem depends on the controlling of these conditions and on the further development of construction and transmission apparatus. We must first be able to express exactly each of the chemical and physical conditions which make up the sum total of the room condition. The criterion of successful design must not be the self-contradictory feeling of people, but must be the exact reading of radiometers, hygrometers, airmeters, apparatus for the analysis of air, dust counters, thermometers and other instruments.

The practical problem is to introduce heat in quantity and form to make the building comfortable. As heat can be introduced by convection currents and by radiation, there will be at least two corresponding temperature conditions in a room. The expression "temperature of a room" commonly means the reading of a correct thermometer in the room. This thermometer does not indicate the temperature of the surrounding air, for it is largely influenced by the amount of radiant energy impinging on the bulb and having no connection with the air temperature. The problem is not solved when the heat causes a thermometer in a room to read a certain figure. Of course, in designing a large system a great deal of calculation is required to obtain a uniform and proportional flow to all parts of the apparatus. Even when this is done a large number of persons undoubtedly cannot endure apparatus heat in any shape.

To get to the bottom of the problem the temperature of the air itself and the temperature corresponding to the radiant conditions should be studied. To make a systematic beginning we must also develop experimental means for recognizing and measuring air and radiant temperatures, and quantities of convected heat and radiant energy. It is necessary to determine experimentally the relation between the thermometer rating, the air temperature and the radiant temperature. The term "radiant temperature" signifies the temperature registered by a thermometer if there were no air in the room at all—a sort of mean of the temperature of the surrounding walls.

Separate instruments have been devised at the University College for registering the air and radiant temperatures. The first shows the mean temperature of all exposed surfaces, such as the walls of the room and the furniture, affecting the bulb of the thermometer. The principle of the instrument is to surround a delicate thermometer with air at the same temperature as that of the room, and also to envelop it with a surface whose temperature can be adjusted to any degree and held absolutely uniform. The instrument for finding the temperature of air is constructed on the principle that a thermometer surrounded both by air and by double-walled surfaces at the same temperature as the air in the room will read exactly the temperature of the room air. If the radiant and air temperatures are made identical, both will be the same as the thermometer reading.

*From a paper read before the Society of Engineers (Inc.), in England, and abstracted in "The Mechanical Engineer."

The author claims to have proved with these instruments that the stuffy feeling often associated with heating systems is caused largely by too high air, and too low radiant temperatures. The freshness of a building depends on keeping the air temperature relatively low and the radiant temperature high. This explains why a room warmed by an open fire often feels much more comfortable than one heated by a radiator. The temperature and humidity of the air are the important points, and not its chemical freshness, freedom from CO_2 or from other organic products.

In this connection it is important to separate the heat communicated to a room as radiant energy from that communicated by warming the air. In an apparatus contrived for this purpose, a canopy collects all the warm convection currents proceeding from the heater. A delicate electrical method is applied for testing the quantity and temperature of the heat. The heater is surrounded by radiant-heat meters, such as radiometers and thermopiles

The effect on the human organism of dust in the air must be determined, but as there are millions of particles per cubic inch, special methods are required for counting them. In the "Aitken" dust counter a minute sample is measured and diluted largely with a known quantity of pure and dustless air. The particles of dust in a fraction of this enlarged volume are deposited on a glass plate underneath a microscope and actually counted. By multiplying by the total number in a cubic inch, the original sample can be calculated.

In no respect has the science of heating and ventilation been more backward than in the knowledge of laws governing the movements of air. The flow of air is brought about by the operation of very trifling momentary and constantly varying causes. So, no doubt, is the flow of electricity in relatively large quantities at low voltages. The ventilating engineer is also concerned with a comparatively large flow of air at low differences of potential. The electrician would find difficulty in investigating the current through a cube of copper measuring three feet in every direction. Local circuits would be set up by any accidental distribution of electromotive force, such as those set up by the movements of a magnet in the neighborhood. This exactly corresponds to the problem with which the engineer is confronted in ventilating a building. Air is introduced, for instance, into a room at a certain point. At other points in the room, sometimes near, sometimes remote, from the point at which the air is introduced, currents of air which the occupants of the room call "drafts," are experienced. It is held up as a reproach to the ventilating engineer that these exist, and so no doubt it is. Yet the laws of pneumatics are quite as definite as those of electricity. The difficulty is in gaging and controlling the working conditions. In developing experimentally the laws of pneumatics on a basis somewhat similar to those of electricity, standard units must be evolved comparable with those of electrical science.

We are experimentally testing the validity in all kinds of pneumatic flow of a fundamental formula similar to Ohm's law. The law may be stated as $H = RQ^2$. The unit of aëromotive force H is naturally a foot of air column, or that difference of pneumatic pressure against which it would require one foot-pound of work to force one pound of air. The unit of flow Q is one cubic foot of air per second. Since the corresponding unit of resistance is closely equal to the resistance of a hole 6 in. diameter in a thin flat plate, a pressure equal to one foot of air column will cause a flow of one cubic foot per second through the hole. If we can compare all pneumatic resistances with this unit, we will understand the flow of air better than when working with the present complicated formulas. The fundamental difference between the laws of pneumatic and of electrical flow is that in the former the aëromotive force is nearly proportional to the square of the flow, whereas with electricity the electromotive force is exactly proportional to its first power. These differences are not sufficient to exclude the application of similar experimental methods. A large apparatus, the pneumatic analogue of the Wheatstone bridge, is used for the determination of pneumatic resistances, and sundry methods of battery resistance have been applied to determine the internal resistance of a fan. If we can specify the proper resistance in pneumatic units for a boiler flue and chimney, we can deal rationally with the much vexed chimney problem. This problem has been treated only in the most incomplete and perfunctory manner. We can determine, by the application of these rules, the actual resistance of a boiler flue, and can tell exactly the maximum capacity of a plant in heat units or in pounds of steam, even without lighting the fire in the boiler. To thus determine the resistance of boiler flues and chimney shaft, it is only necessary to have a fan discharge to the boiler through a chamber in which a constant low pressure of air can be maintained. The resistance between the fan and the boiler inlet is then varied, the current measured, and the pneumatic resistance can be at once established.

It is easy to show that the total resistance of a boiler plant consisting of three Lancashire boilers, 28 ft. by 7 ft. 6 in., with a chimney 100 ft. tall, should be about 0.00172 unit of resistance. It is even possible to determine this resistance without a fan or an anemometer, but with a very accurate micrometer pressure gage. By measuring accurately the pressure in the inlet chambers due to the pull of the chimney, the flow of air through the flues at any given moment can be determined by calculation. The resistance of the boiler flues and chimney in pneumatic units can then be easily found.

Enough has been said to show engineers that there is more in this subject than the collection of rough rules of thumb found in the current literature. At present, heating and ventilation resemble mechanical science at the time of Newton, or electrical science at the time of Faraday. It would be very much to the advantage of mankind if engineers would take more seriously a subject worthy of a high place in practical science.

Results of the Locomotive Boiler Inspection Law*

By Frank McManamy†

The following table shows the inspection work performed each year since the passage of the law three years and eight months ago, and the decrease in the percentage of locomotives reported defective indicates in a measure the improvement in conditions:

	1914	1913	1912
Number of locomotives inspected.....	92,716	90,346	74,234
Number found defective............	49,137	54,522	48,768
Percentage found defective.........	52.9	60.3	65.7
Number ordered out of service......	3,365	4,676	3,377

It does not, however, fully show the improved conditions resulting from the operation of the law, because, as pointed out in our 1913 report, attention was first concentrated on the more serious defects, so that the number of fatalities might be reduced; therefore, the improvement is more accurately indicated by the reduction in the number of casualties, as shown by the following table:

	1914	1913	1912
Number of accidents..................	555	820	856
Decrease from previous year, per cent...	32.3	4.2	...
Decrease from 1912, per cent...........	35.1	...	...
Number killed	23	36	91
Decrease from previous year, per cent...	36.1	60.4	...
Decrease from 1912, per cent..........	74.7	...	...
Number injured	614	911	1005
Decrease from previous year, per cent...	32.6	9.3	...
Decrease from 1912, per cent..........	38.9	...	...

The data cited are taken from the records up to July 1, 1914. A check of the first six months of the present year, that is, from July 1, 1914, to Jan. 1, 1915, in comparison with the corresponding period in the preceding years, shows the following results:

During the period ended Jan. 1, 1914, there was a total of 349 accidents that resulted in injury, with 15 killed and 385 injured thereby. During the period ended Jan. 1, 1915, there was a total of 253 accidents that resulted in injury, with 6 killed and 271 injured thereby, or a decrease of 27.5 per cent. in the number of accidents, 60 per cent. in the number of killed and 30 per cent. in the number injured by the failure of locomotive boilers and their appurtenances.

*From a paper before the Western Railway Club, Chicago.

†Chief, boiler inspection department, Interstate Commerce Commission.

Going back further and making a comparison with the corresponding period for 1912, we find that during the six months period ended Jan. 1, 1913, there were 470 accidents that resulted in injury, with 24 killed and 512 injured thereby. In other words, the number killed by failure of locomotive boilers and their appurtenances during the first half of our fiscal year beginning on July 1, 1912, was 12½ per cent. greater than for the corresponding periods in the two following fiscal years, with almost as great a decrease in the number injured and the number of accidents. Or, to state the whole matter briefly, in three years the number killed by failure of locomotive boilers and their appurtenances has been reduced from about 100 per annum to less than one-fourth that number, and the number injured from more than 1000 per annum to less than one-half that number, with a corresponding decrease in the number of accidents.

WHY LAW HAS REDUCED BOILER ACCIDENTS

These are the direct results of the operation of the Locomotive Boiler Inspection law and indicate the manner in which it is fulfilling the purpose for which it was enacted—to promote safety. The question will no doubt arise as to just what the law has done to produce such results; and in reply I will say that they are due to a number of reasons, among which are more careful inspection, more prompt repairs and attention to minor defects, investigation and classification of every accident that resulted in injury, with a view to determining the cause and remedying it, and giving publicity to the information collected.

FEDERAL INSPECTION PROMOTES BETTER MAINTENANCE OF BOILERS

No railroad man with a trace of honesty and a knowledge of conditions and practices prior to the passage of the law can question the fact that, generally speaking, inspections are now more carefully and more regularly, and repairs more promptly, made, and that the question of repairs is less apt to be determined by the number of loads in the yard awaiting movement, although unfortunately that is still occasionally considered to be the deciding factor; an illustration being a recent request by a master mechanic to operate a locomotive with 43 broken stay-bolts a distance of 312 miles, because they needed the power.

FIREBOX STUDS NEGLECTED

The importance of giving attention to minor defects can be shown by an illustration: During the last fiscal year 18 persons were injured from studs blowing out of firebox or wrapper sheets. In almost every instance they gave warning of their defective condition by leaking before they blew out; and they can be renewed with less expense to the company at that time than after they blow out and cause injury. It should be done, and the practice of repairing leaking studs by calking, or permitting them to continue in service without repairs, should be discontinued.

Investigating every accident to determine the cause, and classifying it so that the number and causes of the various accidents can be readily seen, has been an important factor in shortening the accident list. This information is given publicity in our annual report for the purpose of directing attention to the causes of accidents so that they may be avoided.

FEWER CROWN-SHEET FAILURES

I have recently had occasion to read carefully statements made before Congressional committees at the time the boiler-inspection law was pending, to the effect that all boiler explosions were really crown-sheet failures due to low water, therefore, were man failures which could not be prevented by Federal supervision; and still more recently have listened to a repetition of these statements from a source which would indicate that they represented the consensus of opinion of railroad officials. To correct this misapprehension, attention is directed to the records of such accidents since July 1, 1911.

During the year 1914, as compared with 1912, accidents which are usually termed boiler explosions which resulted in injury have decreased 44 per cent. or from 97 in 1912 to 54 in 1914, and the number of killed and injured has decreased 64 per cent., or from 290 to 104. During the same period crown-sheet faiures due to low water decreased 48 per cent., or from 92 to 48.

I am directing attention especially to this class of accidents, first to show that such casualties as these, which were said to be unpreventable, have been materially reduced, and also because our investigations have shown that by proper application and maintenance of boiler appurtenances they can be still further reduced. I refer to the location, manner of application and maintenance of such appurtenances as injectors, gage-cocks and water glasses.

INCONVENIENT LOCATIONS OF GAGE GLASSES A MENACE

Rule 42 provides that "every boiler shall be equipped with at least one water glass and three gage-cocks. The lowest gage-cocks and the lowest reading of the water glass shall be not less than 3 in. above the highest point of the crown-sheet." While it may be a compliance with the letter of the law to locate these appurtenances where they can be most easily applied, regardless of their convenience to the enginemen, it is manifestly not a compliance with the intent of the law and is not conducive to safety, as an improper or inconvenient location may seriously interfere with their proper use. As an illustration of an improper location, a certain type of locomotive has the water glass directly behind the engineer and out of sight of the fireman. As these locomotives are used in passenger service on a busy division, where it is at times necessary for the engineer to read a signal each 20 sec. or less, it is certain that under such conditions the reading of the water glass will not be as frequent as it would if placed in a more convenient location.

In other instances glasses are found so obscured by other boiler appurtenances or by improper shields that it is difficult, and under certain conditions impossible, to see the water level. A recent investigation of a crown-sheet failure showed that the cab arrangement was such that the water glass and gage-cocks were 9 in. above the engineer's head and that ne regularly carried a small keg to climb upon to try the gage-cocks. Can it be seriously questioned that such conditions cause accidents, particularly when operating in a busy terminal?

Using a shield that obstructs the view of the water glass is also too common. In some instances it has been found that the shield almost entirely obscures the water glass. On deckless locomotives we frequently find the water glass located behind the wind sheet or back wall of the cab, in such a position that only by leaving his usual position and peering intently into the space between the boiler head and wind sheet can the engineer see the water level. On the same type of locomotives we find gage-cocks so located that to try them the enginer must step back out of reach of the throttle, brake valve and reverse lever. The inevitable result is that when busy switching, or when trying to get a tonnage train over a hill on a slippery rail, gage-cocks located out of reach are not used as often as they otherwise would be.

VITAL IMPORTANCE OF CORRECT LOCATION OF BOTTOM GAGE-GLASS FITTING

The manner of application is also important, both as to water glasses and gage-cocks; and in reference to this I will quote a paragraph from a paper I read before this club in 1913:

> Another matter that has not always received the consideration that it should is the location of the bottom water-glass fitting. The opening of the boiler for this fitting should always be above the highest point of the crown-sheet, yet on a large percentage of locomotives they appear to have been located without much regard to the height of the crown-sheet, the proper height of the lowest reading of the glass being obtained by the use of nipples of various lengths. When this opening to the boiler is made below the highest point of the crown-sheet, if the top water-glass cock is closed or the opening restricted, water will show in the glass when there is none on the crown-sheet, and we have records which show that this has been the cause of more than one crown-sheet failure; therefore, I desire to urge the importance not only of having the fitting so applied that the glass cannot under any circumstances show water when the crown is bare, and this means that the fitting should be so designed and located that the proper reading of the glass can be obtained and the opening to the boiler kept above the crown-sheet.

I am referring to this again for the reason that investigations conducted since that time have shown positively that the combination of conditions shown in that paragraph is one cause of crown-sheet failures, one of which occurred quite recently.

GAGE-COCKS AND THEIR DRIPPERS

We also find that the manner in which gage-cocks and gage-cock drippers are applied indicates that the purpose for which they were applied did not receive sufficient consideration. While the application of a dripper is important to prevent the discharge from the gage-cocks scalding anyone in the cab, it should not be so close to the cocks that the nipples extend down into the dripper, preventing enginemen from seeing the discharge, as dripper pipes occasionally become obstructed and fill with water, in which event the sound of water and steam are identical.

This is not offered as an excuse for crown-sheet failures due to low water, because we believe there are no excuses; but our investigations have shown that these conditions are sometimes the cause of such accidents; therefore, sufficient care and foresight should be exercised to so apply all these appurtenances that they will to the best advantage serve the purpose for which they are required.

FREQUENT FAILURES OF INJECTOR STEAM PIPES

Failure of injector steam pipes continues to be one of the most frequent causes of serious accidents, and is the only one which shows an increase during the present fiscal year over the corresponding period for the previous year.

Of 16 injector steam-pipe failures five were due to nuts breaking, one to threads stripping, one to a nut being too large, five to collar or sleeve breaking and four to defective brazing. Each of the accidents due to the nut breaking or stripping resulted from attempting to tighten the joint without shutting off the pressure, for which the remedy is obvious, although perhaps somewhat difficult to apply.

BRAZED JOINTS DANGEROUS UNLESS REINFORCED

The other nine failures, four of which were due to poor brazing and five to collar or sleeve breaking, could, I believe, have been prevented by extending the pipe through the collar or sleeve and flanging or beading it, thus reinforcing the collar and reducing the strain on it, as the end of the pipe itself will be solidly held in the joint; therefore, it will carry the load. If properly applied in this way, brazing is not necessary, although it can be done if desired. This method of application is at least as cheap as brazing, and defective or improper workmanship can be discovered by inspection, which is impossible with the brazed connection.

The discussion on the location of the bottom fittings of gage-glasses was to the effect that that fitting should always be placed above the highest point of the crown-sheet, notwithstanding the complaint of some engineers that such location prevents a timely warning of foaming.

Fuel-Oil for Locomotive Use*

From 1907 to 1914 the use of fuel oil by railroads increased 112 per cent., until a total of 31,000 miles, distributed over 50 railways, was operated with this fuel. For a time during the years 1912 and 1913 there appeared to be a tendency to discontinue the use of oil, on account of the great demand for the distilled products of crude oil used for other purposes, leaving a diminished supply of fuel oil and residuum. Opening up of new fields, more efficient methods of distillation, the production of gasoline from natural gas, etc., have again increased the fuel oil supply, and its use is again extending.

In the combustion of fuel oil, where a steam spray is used for vaporization, we are confronted with the fact that in the process of atomization the particles of oil are started on their way to the flues even before they are partly burned. The first result of these particles coming into the heated portion of the furnace is to separate the carbon from the hydrogen, the former thus being left as a fine dust floating in the furnace in such a manner as to be easily carried to the flues unconsumed, to be deposited as an insulating layer of soot, or to be carried out of the stack in the form of black smoke. If these fine particles of carbon were attached, as in a bed of coals, a supply of air could easily complete their combustion. With liquid fuel, therefore, the diffusion must be simultaneous with ignition, with the resultant long flame. The surface tension of oil, especially when the particles are finely divided, is such as to make the drops assume a spherical form of extreme rigidity and therefore expose the least possible area to the oxygen. We are thus brought to realize that large furnace volume is essential to the burning of fuel oil. While the relative dimensions are of minor import to the volume, it is evident that a flame passage of sufficient length to prevent unconsumed particles passing to the flues must be provided. It was the realization of the limited volume of the locomotive furnace that brought about the change from back- to front-end burner arrangement a few years ago, in an attempt to lengthen the flame path.

While it is generally conceded that lack of oxygen is responsible for smoke, the restricted furnace volume and the attending lack of time for the proper mixture of the gases in the more highly heated portion of the furnace is the most common cause for black smoke from an oil-burning locomotive. One of the difficulties met with in the use of oil in the locomotive is the frequent necessity for the removal of soot from the flues, by means of sanding out. This, of course, is attended with several disadvantages, not the least of which is the resultant loss of fuel.

Special attention is brought to this point in connection with locomotive oil-burner furnace design because of the general tendency to restrict the furnace volume by carrying draft pan and brickwork too high in the firebox, covering up valuable heating surface and bringing about the continual necessity for forcing the fire at the expense of the remaining exposed surfaces.

*Abstract of paper read by G. M. Bean before the International Railway Fuel Association, Chicago, May 17-20, 1915.

One of the principal requirements in the burning of oil is to expose the fuel to the furnace heat so that the greatest possible area is presented to the oxygen. A study of the atomization of oil is therefore of some importance, and it will be readily seen that the stretching of the surface of fuel oil is a study of capillary action and that it is not hard to determine the work necessary. Oil in bulk has little surface, but when broken up into fine particles it has the combined surface of the spherical areas of the drops thus formed, and the work of atomization is the work of stretching the surface of exposure.

Theoretically, it should be possible to atomize oil to a definite fineness of spray by means of a mechanical device much more economically than by means of the steam jet.

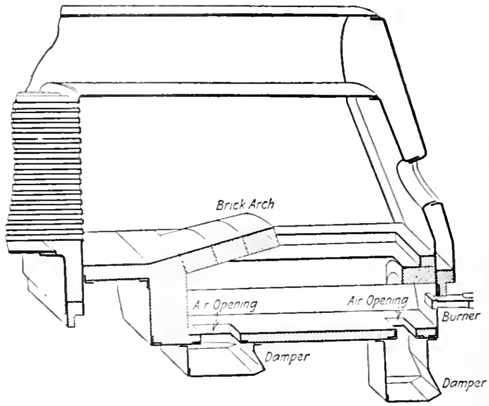


FIG. 1. BURNER AT BACK OF FURNACE

Many attempts have been made along this line, with almost as many failures. The simplicity and flexibility of the steam-jet burner make that method difficult to improve, and the fact that the type of burner now in use on the majority of locomotives is practically the same as the one first introduced in this country would lead to the belief that when improvement is made in the oil-burning locomotive furnace, it will not be made in the burner. One of the simplest of all burners and now standard on the Santa Fé Ry. has been in continuous use on that line since oil was first introduced as fuel, and has never failed, in itself, to show up well in connection with any furnace design. In other words, where failures in design or arrangement were met with, it was always traced to other features being wrong, rather than the burner. The type of burner therefore seems of minor importance, so long as it is simple, substantial, not easily stopped up and easily cleaned.

Locomotive furnaces are not considered ideal for the use of fuel oil, and for this reason as much as any other there have been as many different furnace arrangements as there have been localities in which oil fuel has been used.

At the first inception of the idea in this country it was natural that the designs used in Russia should be followed. The burner was placed under the rear of the firebox, Fig. 1, and directed forward with an upward incline, so that the flame shot under a low, short brick arch, with the result that combustion became so intense in this limited space as to cause the flame to pass from under the arch with such velocity as to impinge on the door-sheet, side-sheets and crown-sheet, with detrimental results. Bad water conditions throughout the Southwest aggravated this to such an extent that the life of fireboxes was only about eighteen months or two years, and the replacing of them soon became a severe burden. The back-end burner arrangement also required an excessive quantity of firebrick, which not only gave trouble by continually burning out, but also served to cover up valuable heating surface, restrict the furnace volume and throw an increased load on the remaining heating surface.

While the back-end burner arrangement is still in use to some extent throughout Texas, it has entirely disappeared from every other section. The burner is now placed in the front end of the draft pan, Fig. 2, and directed toward the rear in such a manner that the draft is forced to reverse the direction of the flame before it passes to the flues. The furnace is open, the brickwork is kept low and the maximum of heating surface is exposed. The correct drafting of this arrangement is still a somewhat debatable subject, but the general idea seems to favor the admission of the principal volume of air through openings in the vicinity of the flash-wall, which is built up under the door, it being the plan to admit this air through numerous small openings, preferably circular in shape and distributed well over the rear third of the draft pan in such a manner that the air is brought in contact with the flame from several directions and not in too concentrated a volume. A small amount is also admitted around or under the burner, so as to prevent it from overheating and to keep the flame from dragging on the floor of the pan. This arrangement results in a uniform distribution of heat and the consequent lengthened life of the fireboxes and flues, until it can safely be said that for service under like conditions, a firebox on a locomotive burning oil will last longer than one in a coal burner if consideration is given to the extra work possible to be obtained from the oil burner.

Oil requires from 20 to 30 per cent. more air per pound of fuel than the average bituminous coal. There is a tendency to restrict the air openings in draft pans of oil burners, and it is generally the rule that with locomotives of the same class in both oil- and coal-burner service, the oil burner will have the smaller nozzle, indicating the necessity for maintaining a higher front-end vacuum to draw in the necessary amount of air to make the engine steam properly. This is attended with the added difficulty that the high velocity of the entering air produces a more concentrated column or stream, which is difficult to break up, requiring a heavy atomizer, the use of which has its disadvantages.

There is a question whether the open furnace created by the front-end burner arrangement is all that can be desired, for it is true that the gases will follow the path of least resistance and the velocity at the center of the combustion space will be much higher than at the sides, this indicating the necessity of some sort of a baffle to increase the velocity of flow at the top and sides where the gases wipe the heat-absorbing firebox sheets. It is also apparent that when the flame path is surrounded by heat-absorbing surfaces to hasten the process of diffusion and shorten flame length, the subjecting of the gases to the presence of incandescent baffles is desirable.

Aside from the two furnaces outlined there is in service on one of the Southwestern railways, as well as on some Mexican railways, the arrangement shown in Fig. 3. This differs from the others in that it has a burner in both the front and the rear of the draft pan, directed toward each other, the line of flame of the front burner being slightly higher than that of the rear. This furnace also has the advantage of the low brickwork and large exposed heating surface. In fact, the opposing burners do away with the necessity for a high flash-wall under the door.

Fig. 2. Front-End Burner Furnace

In the two last-named types it is the practice to keep the brick low on the sides and expose all possible heating surface. Firebrick for this service must be of good quality, as the firebox temperatures range from 2500 to 2750 deg. F., which, with the fluxing action of the salt and alkalies carried in the oil, are severe on the furnace and cause it to give out readily, making frequent renewals necessary. The proper maintenance of brickwork is essential to good results, and the possibility of the brickwork falling down in the path of the flame must be avoided, as it usually results in an engine failure.

The oil supply is carried in tanks built to fill the coal space of the tender and piped from there through suitable connections to the burner. It is generally necessary to provide means for heating the oil so as to insure a proper flow, as gravity is depended upon for the necessary pressure. This heating is also an aid in atomizing, and various means are provided for the purpose. The original practice was to turn steam directly into the oil, but aside from an emergency feature, this has been generally abandoned, as the accumulation of condensation gave trouble in disposal, as well as by getting into the oil line and interfering with the burner operation. The draining of the condensation from the tank was always accompanied by some loss of oil, and the direct heating often resulted in overheating the entire contents of the tank, with the attending loss. An improvement was to place steam coils in the space and heat indirectly. This had some advantages, but it also caused trouble by overheating and by the pipes leaking at the joints. It is probable that the box heater is the most desirable arrangement. It is indirect in its action, only heats a sufficient volume to insure a supply at the burner and is not liable to cause trouble by allowing water to get into the oil storage.

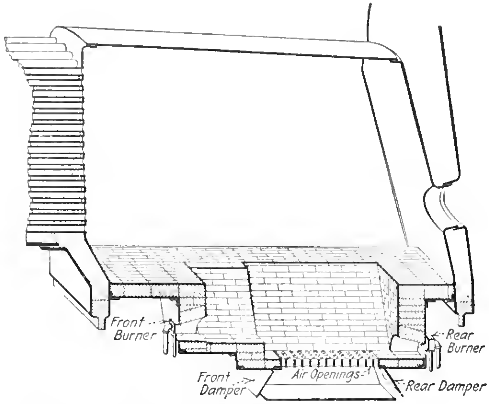


Fig. 3. Burner and Brick Arrangement in the Hammel Furnace

The oil-storage tanks are provided with suitable gages or measuring devices to give a check on their contents at all times. Means are also provided for cutting off the supply of oil to the burner in case of accident, such as a wreck or a break between the engine and tender. The supply of oil is regulated by means of a suitable valve placed near the burner and operated through connections by the fireman. In some climates it is necessary to provide an auxiliary heater in the pipe line to reheat the oil before it goes to the burner. Such a heater should be used only when necessary, as extensive heating tends to carbonize the fuel in the oil-supply line and the burner.

Emphasis should be placed on the fact that the oil fireman is an important factor in the success of the operation of oil-burning locomotives. He must intelligently follow every movement of the engineer that demands regulation of the fire. He has two gages to guide him—the top of the stack and the steam gage. That is, the proper steam pressure must be maintained with the least possible smoke. A thin gray color at the top of the stack is usually indicative of proper combustion.

Given a modern locomotive with a furnace designed along the lines indicated, with equipment in proper adjustment and an intelligent engine crew, the result should be of as high an order as is so far attainable with steam-operated motive power.

New York State N. A. S. E. Convention

The twentieth annual convention of the New York State Association; N. A. S. E., was held June 11 and 12 at Auburn. Upward of fifty delegates were in attendance at the business sessions, which were held in Woodmen's Hall. The first floor of this building was arranged for the use of exhibitors. The convention was called to order Friday morning by F. J. De-Witt, chairman of the local committee. He introduced City-

Att[illegible] William S. Elder, who welcomed the delegates in the absence [illegible] Mayor Charles W. Fraster. State-President Frederick [illegible] responded to this address of welcome. The next [illegible] was Charles G. Adams, secretary of the Auburn Chamber of Commerce, who gave a description of the manufacturing resources of the city. National Vice-President Walter [illegible] of Buffalo dwelt briefly on the aims and principles of the association. He was followed by Past-National-President Reynolds, of New Jersey, who outlined the aims and plans of "The National Engineer." State-President Felderman then called the business meeting to order and announced the various committee appointments.

A feature of the convention was a luncheon given to the delegates and guests at the Osbourne House, through the courtesy of the McIntosh & Seymour Corporation. Afterward, special cars conveyed the party to an inspection of the company's plant. The entertainment program also included an illustrated lecture on oil and steam engines, given under the auspices of the McIntosh & Seymour Corporation, an inspection of the Auburn prison, a trip to the plant of the Empire Gas & Electric Co., and auto rides for the ladies to points of interest in the city.

A pleasant surprise to State-President Felderman was the presentation of a handsome clock. A silver service tray was given to his wife. Past-National-President Reynolds made the presentation addresses. A memorial service for members who had passed away during the past year was conducted by Vernon N. Yergin, pastor of Calvary Presbyterian Church. At the closing session Niagara Falls was chosen for the June, 1916, meeting. The state officers unanimously elected were: William H. Aydelotte, of Niagara Falls, president; William Downey, New York City, vice-president; William Roberts, Yonkers, secretary; William Downes, New York City, treasurer; Joseph C. Butrich, conductor; George Ely, doorkeeper; and David Larkin, chaplain. William Bedard was chosen to succeed himself as state deputy.

The exhibitors were as follows:

Albany Lubricating Co.
Amer. Steam Gage & Valve Co.
Anderson Co., V. D.
Auburn Woolen Co.
Burg & Hill
Clapp Mfg. Co.
Columbian Rope Co.
Crandall Packing Co.
Cross, Orrin C.
Cuddy & Geherin
Dearborn Chemical Co.
Dunn McCarthy Co.
Eccles Co., Richard
Engineering Supply Co.
Garlock Packing Co.
Garrett Coal Co.
Henry & Allen
Herron Hardware Co.
Home Rubber Co
International Harvester Co.
Interstate Machine Co.
Johns-Manville Co., H. W.
Keystone Lubricating Co.
Lunkenheimer Co.
McIntosh & Seymour Corp.
McLeod & Henry Co.
"National Engineer"
New Birdsall Co.
Otis Elevator Co.
Peerless Rubber Mfg. Co.
"Power"
Quaker City Rubber Co.
Roebling Sons Co., John A.
Smith & Pearson
Wadsworth, David & Son
Woodruff & Murphy.

DELEGATES TO NEW YORK STATE N. A. S. E. CONVENTION, IN FRONT OF AUBURN STATE PRISON

Co-operators

To conserve and continue the work done by Frederick W. Taylor, the initial steps have been taken to found an organization to be known as the Frederick W. Taylor Coöperators. In harmony with Mrs. Frederick W. Taylor's request, James M. Dodge, Carl G. Barth, Morris L. Cooke and H. K. Hathaway have taken the initiative and have issued a preliminary letter stating the purpose of the organization. This is to gather books, data and other material that would be of use in a biography or for a memorial to Mr. Taylor, and to provide for the continuation and extension of the Taylor System of Management.

Rear Admiral Isherwood Dead at 92

Benjamin Franklin Isherwood, engineer-in-chief of the United States Navy during the Civil War and one of the founders of the experimental theory of the steam engine, died at his late residence in New York on June 19, in his 93d year. Born Oct. 6, 1822, in New York City, he was a great-grandson of a distinguished French military engineer, Captain Du Clos, an officer on General Lafayette's staff in the American Revolution. His early schooling was received at the Albany Academy, where he studied natural philosophy under Joseph Henry, after which he entered the employ of the Utica & Schenectady R.R., and later went to work on the construction of the Croton aqueduct, on its completion entering the service of the Erie R.R.

His entry into governmental service was under the Lighthouse Board, where he seems to have performed work of responsibility, for he was sent to France to superintend the construction of some lighthouse lenses from designs by himself. The steam-engineering corps of the Navy was meanwhile being organized by Charles H. Haswell, and Isherwood was one of its earliest appointees, being made first-assistant engineer, and in 1848 was promoted to chief engineer. Meantime the Mexican War had been fought and he had been an active participant on shipboard; in fact, he was in every naval action. He served on the "Princeton," the first American screw steam vessel, and later on the "Spitfire." After the war he cruised for three years in the "San Jacinto," attached to the Asiatic squadron.


Late Rear Admiral Isherwood

One of the earlier performances that brought Isherwood professionally into notice was the design of alterations for the engines of the "Allegheny," 1851-52. He arranged the cylinders with a back-acting motion in a manner which anticipated the type of engine afterward bearing his name. The device showed his mechanical ingenuity, although the vessel as a whole was not a success, and the experience taught him in future designing to provide engine frames strong enough to allow for weakness in the hull, a point which was especially important when so many old vessels, many of which were of light construction, had to be equipped during the Civil War.

At the outbreak of the Civil War, Isherwood, although some distance from the top of the list, was appointed to the responsible position of engineer-in-chief of the war navy. His appointment was dated Mar. 26, 1861. Not only did he evince a dependable zeal for the Federal Government—which, at a time when so many officers were going over to the Confederacy or wavering in their allegiance, was no small recommendation—but his professional qualifications were of an exceptionally high order. For many years past he had given his attention to systematic experimental research in steam engineering, where he had done splendid work and was probably the leader in America. The result of some of these researches had been given to the public, notably in 1859, in a book entitled "Engineering Precedents," which embodied his studies on the indicated power of engines, frictional losses, power expended in actual propulsion of vessels, etc. It is interesting to note that this book had the first published indicator diagrams reproduced from actual engines.

The task confronting Isherwood upon his appointment was that of evoking a new and large navy out of nothing, or next to nothing, in a short period. At the beginning of the war the Government had only 69 vessels of all classes, 34 of them being sailing ships. By the end of the year 1861 it had improvised a navy amounting to 211 vessels, with 2301 guns and 20,000 men, which by the close of the war had grown to 600 vessels of all classes.

One of the reasons for Isherwood's success was his strong common sense, which was shown particularly in the design of the machinery built during the Civil War. Although the adoption of a low ratio of expansion, and hence high mean pressure, gave him small engines, the machinery was very heavy. Designers working 30 or 40 years later, with improved materials, have criticized this machinery, forgetting one point with which Isherwood was supreme—this machinery was designed for war vessels, and it was absolutely essential that it should not break down. The enormous expansion of the Navy led to the employment of large numbers of patriotic but comparatively unskilled engineers. To have intrusted delicate machinery to such men would have been to run the risk of disaster. For the same reason, such expansion as was obtained depended only on the ordinary Stephenson link, there being no separate and complicated cutoff gears. But almost incredible was his ability to find time for the continuation of elaborate scientific investigations, to profit by his unrivaled opportunity for practical experiments, and even during those busy years to publish in huge volumes the results of his researches.

In 1863, when swift cruisers were coming into use, speed qualities received especial attention. About this time the rivalry in design between Isherwood and Ericsson was carried out in the construction of twin 4200-ton ships—the "Madawaska," with engines of Ericsson's design, and the "Wampanoag," fitted with Isherwood engines. The latter had a pair of 100-in. cylinders with 4-ft. stroke and wooden gears, to make 2.04 revolutions of the screw for each double stroke of the piston.

Here, again, we note an illustration of Isherwood's sound common sense. The machinery, which for the time was extremely powerful, was to go into a relatively light wooden hull, and to have used direct-driven engines would have racked the hull. Ericsson's engines were of the same size, but directly connected to the shaft. In the trials the "Wampanoag" made a wonderful record for those days, attaining an average speed of over 16 knots in a winter's sea, and during several periods of a six-hour run over 17 knots were obtained. The "Madawaska" also was capable of high speed, but she could not stand the racking. This did not disprove Ericsson's essential correctness in having, long ago, come out as an advocate of direct, ungeared connections, but the abnormal narrowness of the vessel created a special condition to which the design of her machinery was not adapted. Not for 21 years was the "Wampanoag's" speed again reached in the Navy.

In the early personnel struggles, Isherwood was a champion of his corps. He contended that naval engineers required not only technical training, but theoretical education, and should possess official rank, which has since become established. It is largely to him that we may credit the Congressional Act of 1864 providing for the education of midshipmen as naval constructors or steam engineers.

After serving as engineer-in-chief for eight years, covering the stressful period of the war, Isherwood was succeeded, in 1869, by James W. King. The remainder of his term in the service was largely taken up with special duties. His experiments with screw propellers at Mare Island are scarcely less famous than the expansion tests and those on the economy of compound engines.

By operation of law he retired in 1884 with the relative rank of commodore (since raised to rear-admiral). More than a quarter of a century of life was still in store for him, however. He made his home in New York City, interested and active in research, scientific and literary work, and indulging in extensive tours abroad. The published output of his life in books and papers has been considerable. His "Experimental Researches in Steam Engineering," compiled in Civil-War times, has become a classic, and, as the late Dr. Thurston pointed out, "his conclusions, once ridiculed, are now the basis of the modern engineer's practice."

OBITUARY

BEN B. LAMPREY

Ben B. Lamprey died June 14, at the age of 68, in Westfield, Mass. He was born in Moultonborough, N. H., and in his younger days conducted a hotel and ran a steamboat line at Lake Winnepesaukee. He was the inventor of the Lamprey arch plate and of other devices for low-pressure steam boilers, and was the owner of the Lamprey Boiler, Furnace & Protective Co., of Boston.

PERSONALS

M. A. Hudson, formerly vice-president and general manager of the J. E. Lonergan Co., Philadelphia, Penn., has become general manager of the Central Western branch, United Roofing & Manufacturing Co., with headquarters in the Marquette Building, Chicago.

J. N. Oswald, formerly a member of the engineering department of the Pittsburgh Ry. Co., has been appointed mechanical engineer with the Vacuum Oil Co., Pittsburgh. He was the first erecting engineer of the Nagle Corliss Engine Works, of Erie, Penn., and was for 11 years at the head of the power department of the Gould Coupler Co., Depew, N. Y. Mr. Oswald is president of Pittsburgh No. 3, N. A. S. E.

Osborn Monnett, after a creditable service of four years as chief smoke inspector of the City of Chicago, has become associated with the Institute of Thermal Research of the American Radiator Co., Chicago. In this connection he will offer his services to smoke commissions and smoke inspectors throughout the United States and in every way possible coöperate with those interested in the movement to standardize smoke ordinances and to abate the smoke evil in the heating field. Mr. Monnett was an associate editor of "Power" before taking the Chicago position.

ENGINEERING AFFAIRS

The Canadian Association of Stationary Engineers will hold its annual convention July 20-22, at Hamilton, Ont. It is expected that the attendance of delegates and the display of exhibits will be larger than ever before. The local committee, with the assistance of the officers of the Exhibitors' Association, has arranged an enjoyable entertainment program.

The New England States Association of the National Association of Stationary Engineers will hold its annual convention in Holyoke, Mass., July 7-10. The Nonotuck Hotel has been selected as the headquarters. The meetings of the delegates will be held in the large hall of the Temperance Building, and the City Hall has been secured for the exhibits. An enjoyable program of entertainment has been arranged by the local engineers' committee and by a committee of the supplymen.

TRADE CATALOGS

International Nickel Co., 43 Exchange Place, New York. Catalog. Monel metal. 12 pp., 4x8½ in.

General Electric Co., Schenectady, N. Y. Bulletin No. 42,552. Motor generator sets. Illustrated, 28 pp., 8x10½ in.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin 34-X. Class A-G "Giant" gas and gasoline engines. Illustrated, 8 pp., 6x9 in.

Fisher Governor Co., Marshalltown, Iowa. Bulletin Catalog. Pump governors, reducing valves, pressure regulators, etc. Illustrated, 6½x9½ in.

Ingersoll-Rand Co., 11 Broadway, New York. Form No. 3031. Ingersoll-Rogler Class FR-1 air compressors. Illustrated, 24 pp., 6x9 in. Form No. 4034. Leyner-Ingersoll water drill. Illustrated, 4 pp., 6x9 in.

A. S. Cameron Steam Pump Works, 11 Broadway, New York. Bulletin No. 104. Station and sinking pumps. Illustrated, 36 pp., 6x9 in. Bulletin No. 150. Double suction volute centrifugal pumps. Illustrated, 16 pp., 6x9 in. Bulletin No. 151. Turbine centrifugal pumps. Illustrated, 20 pp., 6x9 in. Bulletin No. 152. Single suction volute centrifugal pumps. Illustrated, 8 pp., 6x9 in. Bulletin No. 153. Centrifugal pumps for house service. Illustrated, 8 pp., 6x9 in. Bulletin No. 300. Triplex pumps. Illustrated, 4 pp., 6x9 in.

NEW EQUIPMENT

ATLANTIC COAST STATES

Bids will be received until 2:30 p.m., June 29, by E. S. Elwood, Secy., State Hospital Comn., Capitol, Albany, N. Y., for the construction and equipment of a power house and electrical work at the Middletown State Homeopathic Hospital, Middletown, N. Y.

The Board of Education, Paterson, N. J., has engaged Lewis E. Eaton, Consult. Engr., to prepare plans for a light and power plant for the High School. An appropriation of $5000 has been made for the work.

SOUTHERN STATES

An election will be held June 29 in Orangeburg, S. C., to vote for a bond issue of $15,000, the proceeds of which will be used for the improvement of the municipal electric-light plant. Edward Howes is City Engr.

The City Council of Cordele, Ga., will engage an engineer to prepare plans and estimates for the construction and operation of a municipal electric-light plant in Cordele.

At a recent election the citizens of Toccoa, Ga., voted in favor of issuing $35,000 in bonds to be used for the installation of a municipal electric-light plant.

CENTRAL STATES

The Falls Rubber Co., Cuyahoga Falls, Ohio, is having plans prepared for a one-story brick and steel power house for its plant. Ernest McGeorge, Leader-News Bldg., Cleveland, is Engr.

It is reported that the Ohio Public Utilities Commission has authorized the Dayton Power & Light Co., Dayton, Ohio, to issue $172,000 in additional capital stock, the proceeds of which will be used to increase the output of the plant from 20,000 to 30,000 hp.

The City Council of Wellsville, Ohio, will soon advertise for bids for the sale of $60,000 in bonds, the proceeds of which will be used for the construction of a municipal electric-light plant.

It is reported that bids will be received until July 12 by the Wernette-Bradfield-Meade Co., Arch. and Engr., Grand Rapids, Mich., for the construction of a power plant for the Imperial Furniture Co., Grand Rapids.

It is reported that the City of Petoskey, Mich., is preparing to rebuild the municipal electric-light plant. J. W. Lovelace is Mgr. and Supt.

The Town of Three Rivers, Mich., is reported to have $50,000 in bonds available for the construction of a municipal electric-light and water-works plant. George Champe, Toledo, Ohio, is Consult. Engr.

WEST OF THE MISSISSIPPI

It is reported that the Des Moines Electric Co., Des Moines, Iowa, contemplates the construction of a 44,000-volt transmission line to Knoxville, Iowa, to furnish energy to the Knoxville Electric Co.

(Official)—Bids will be received until July 1 by the City Council of Davenport, Neb., for the installation of an electric-light plant to cost about $5000. Charles F. Sturtevant, Holdrege, Neb., is Consult. Engr. Noted June 22.

The City Council of Holdrege, Neb., has extended the franchise of the Holdrege Lighting Co. for a period of 25 years. The company has agreed to reduce its rates for lighting and will make various improvements in its plant.

The Union Light, Heat & Power Co., Fargo, N. D., is enlarging and improving its power station, and will install new equipment, including two 1500-kw. steam turbines, two water-tube boilers, a three-unit motor generator set of 600 hp., boiler feed pump, exciters, switchboard, etc. M. L. Hibbard is Mgr.

(Official)—Bids will be received until 2 p.m., July 15, by John A. Ryan, Secy., Bd. of Pub. Wks., Chillicothe, Mo., for installing in the municipal electric-light plant the following equipment: One 375-kw., three-phase, 60-cycle, 2300-volt generator, direct-connected to a steam engine or steam turbine to operate condenser, with separate exciter, switchboard panel and instruments, power circuit panel, etc.; one 500-g.p.m. motor-driven centrifugal pump, for use with condenser, and one 12-in. barometric condenser, one 12-in. horizontal oil separator, and the necessary pipe, valve fittings, etc., required to install the pump and condenser. Harper & Stiles, Grand Ave. Temple, Kansas City, is Consult. Engr.

The Missouri Public Utilities Co., Cape Girardeau, Mo., has been granted a franchise to construct a transmission line from its power station at Charleston, Mo., to East Prairie, a distance of 12 miles, to furnish electrical service to the latter place.

It is reported that H. W. Wright and Thomas Peterson, both of Peoria, Ill., are considering plans for the installation of an electric-light and power plant in Fulton, Mo. Energy for the operation of the plant will be obtained from the Keokuk Electric Co., Keokuk, Iowa.

Henry S. Grimes has made application to the City Council of Lowry City, Mo., for a franchise to install an electric-light plant in Lowry City.

It is reported that the City of Brownsville, Tex., is considering the sale of the municipal electric-light plant to a company which will also take over the street-railway company and combine the two properties. J. W. Davis is City Engr.